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THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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A QUARTERLY JOURNAL DEVOTED TO:

Telephones, Telegraphs (Aerial, Underground, Submarine and Wireless) and all matters of interest to Communication Engineers.

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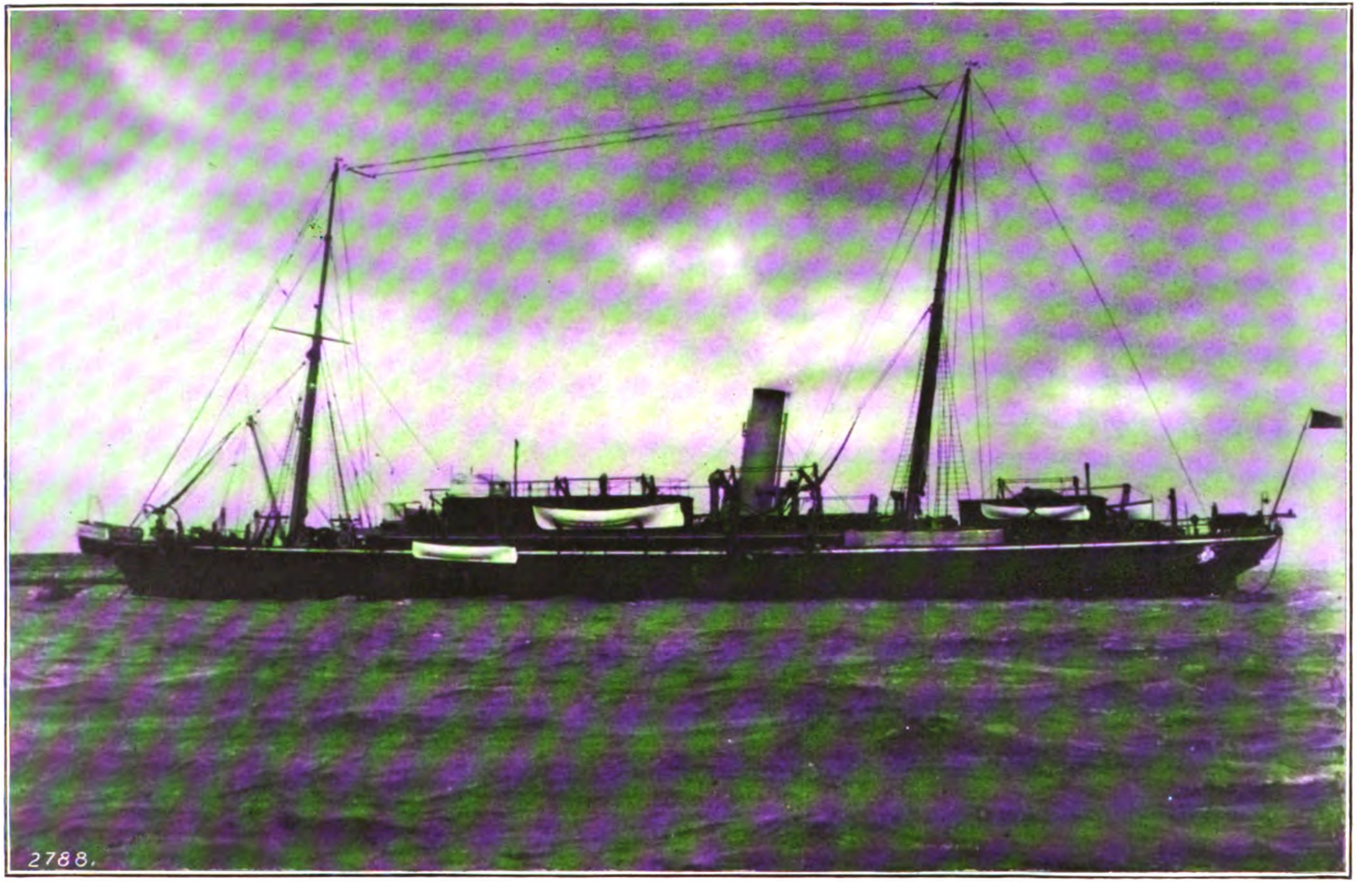


H.M.T.S. "MONARCH" IN KINGSTOWN HARBOUR.

THE
Post Office Electrical Engineers' Journal

ANGLO-IRISH (LOADED) TELEPHONE CABLE.

In the last issue of the Journal there was an article giving the electrical data and details of the construction of the new loaded cable recently laid between Nevin and Howth, and the following notes on the laying operations will probably be of interest.

A view of H.M.T.S. "Monarch" is given in the frontispiece. The "Monarch" not being large enough to take the whole sixty-four nauts on board, the cable had to be laid in two halves.

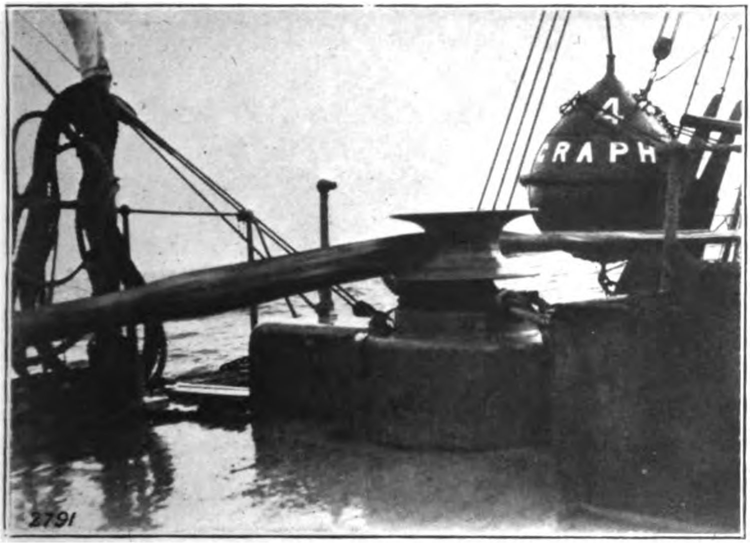
The shipment of the first half of the cable from the works of Messrs. Siemens Bros., Woolwich, to the "Monarch" commenced on the evening of October 29th last, and finished on November 1st. On October 31st Sir A. F. King paid a welcome visit to see the cable being taken on board, and he also made a survey of the ship.

Late in the afternoon of Saturday, November 1st, the "Monarch" left the Thames for Nevin on the North Wales coast. On Sunday morning, owing to a strong south-westerly gale and a very rough sea, the vessel had to be anchored off Deal for four hours before the conditions moderated sufficiently to allow the voyage to be continued. During Sunday night the wind and sea again increased, and the ship, heavily laden as it was, encountered such bad weather that progress was very slow, a speed of only three knots, as against the usual ten knots, being obtained. The bad weather conditions prevailed until the "Smalls" was passed, and the passage consequently occupied more than double the normal time, the Abergeirch Hut (shown in 1) not being sighted until daybreak on November 6th. On this date the weather was comparatively calm, and it seemed as though the luck had turned, a good day's work being done. Six buoys, to indicate the correct route for the cable, were placed at intervals of about five nautical miles, and in addition a "mark" buoy inshore and one beyond the outermost buoy were also placed. Early on the morning of the 7th the "Monarch," lying about half a mile off the coast, sent the steam launch ashore for the writer and Messrs. Dieselhorst and Dyke, the representatives of Messrs. Siemens Bros. It was soon evident, however, that the luck had again turned against Mr. Pollard, the sea, breaking roughly

1.—Abergeirch Cable Hut, Nevin.

2.—Recharging the Buoy-lamps.

on the shore, making it impossible to land the cable end. It was therefore decided to steam along the proposed course to check the line of buoys and renew the oil in the lamps on the outer buoys, which had to be lighted as a guide for the ships passing north and south. The recharging of the lamps during a rough sea appears to a layman to be a risky operation. **2** shows the work being done at one of the buoys. The bad weather which continued during the three following days prevented a start being made with the cable-laying, and it was not until the 11th that the conditions moderated sufficiently to allow the landing operations to be carried out. At four in the morning the "Monarch" anchored off the landing place, the shore end was transferred to a raft consisting of two large life-boats, and the cable paid out. Before eight o'clock this work was completed, and the "Monarch" immediately proceeded to sea, paying out at the rate of five knots. During the morning the wind increased to a gale of exceptional violence and the sea became very rough, making the task of cable-laying no light one. The outer end of the Welsh half of the cable is laid at the deepest part of the channel (70 to 80 fathoms), and the ship becoming lighter and lighter in draught as the paying out proceeded, the utmost difficulty was experienced in keeping the ship to the course during the laying of the last six miles of cable. In **3** a loading-coil is seen passing out at a speed of five knots. **4** shows the cable passing over the bow, the list of the vessel giving some idea of the weather conditions.



3.—LOADING COIL PASSING OUT AT SPEED OF 5 KNOTS.

There was a feeling of great relief when, at about three o'clock in the afternoon, the cable end was passed out and buoyed.

The "Monarch" immediately proceeded to Holyhead, and was compelled to lie there for nine days, during which time the weather conditions were too bad to allow the buoys to be picked up. As there appeared no prospect of the weather improving, it was eventually decided to leave the buoys and return to Woolwich for the second half of the cable. During the stay at Holyhead the "Monarch" shipped sixty tons of coal in twenty minutes from the L. & N.W. Railway Company's special mechanical loading collier, see **5**. This collier is capable of coaling the Company's steamers, for which work she was designed, at the rate of three and a half tons per minute.

4.—Paying out Cable; Bow Baulk Watch.

It will be readily understood that the strain on the officers and crew had been very great indeed, and it was necessary, much to the regret of all on board, to land at Rosslare the popular chief navigating officer (Mr. Broadbridge) suffering from a serious nervous breakdown.

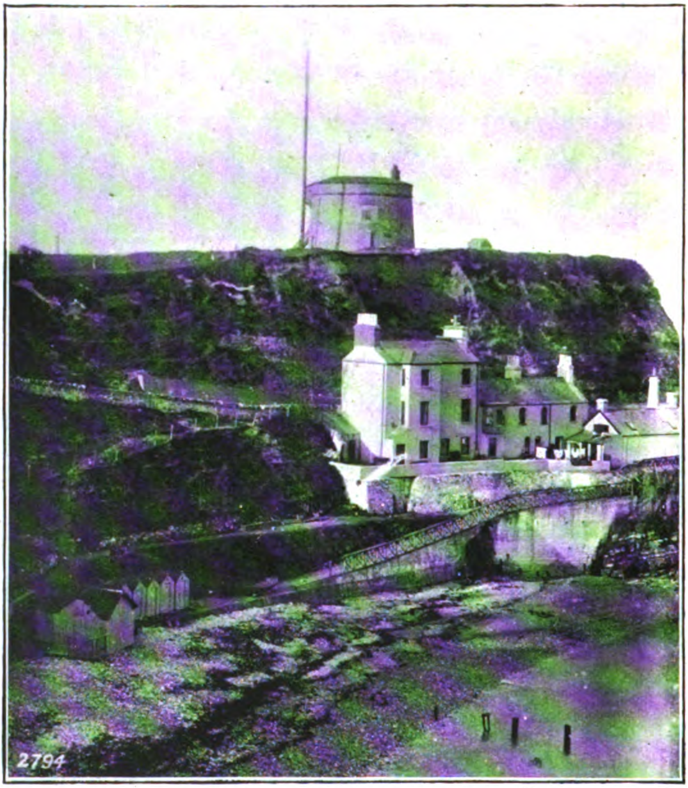
Woolwich was reached on November 24th, and three days later the "Monarch" left for the cable ground with the second half of the cable. The buoys on the Welsh side were picked up, and on December 1st the second series were placed in position on the Irish side. The Engineer-in-Chief joined the ship on that date to see the second half laid, but the weather was so very bad on the five following days that cable-laying was impracticable. It was not until

Sunday, December 7th, that the Irish end could be landed at Howth. 6 shows the landing place, the Martello tower seen in the photograph being used as a cable hut.

The "Monarch" left Kingstown at three in the morning, and after landing the shore end, the laying of the second half commenced shortly after nine, the buoyed end of the first half of the cable being reached about 3.30. It was then found that the cable was short by about two hundred yards, and efforts were made to pick up the slack on the Welsh side until darkness prevented further operations. The ship was kept close by the buoy all night in order to continue the operations at daybreak. Unfortunately on the following day the weather was again stormy and the greatest difficulty was experienced in handling the ship relieved of its cargo. Bad weather continued for several days, and when at last it was possible to proceed with the operations a fault was discovered on the Irish side. The cable had been mechanically damaged by fouling something on the sea bottom, resulting in the cores being crushed. Owing to the weather conditions, considerable difficulty was experienced in picking up and relaying the cable, and it was not until 9.15 p.m. on December 13th that the last splice was completed and slipped overboard. At 10.15 p.m. the very welcome report was received from the testing officers at Nevin that the cable tested satisfactorily.

5.—Coaling the "Monarch" in Holyhead Harbour.

Thus ended one of the most arduous operations ever undertaken by the Department's Submarine Staff. During the whole period of the Commission every conceivable difficulty had been experienced; the few hours of daylight, the persistent bad weather and rough seas, the exceptional difficulties in landing, and, finally, the damage to the cable in mid-channel all contributed to throw a severe strain on the staff, and it is impossible to speak too highly of the zeal and *esprit de corps* of all the officers and men under the command of Mr. Pollard during a time of unparalleled difficulty, not to say of danger.



6.—HOWTH CABLE HUT.

It must be remembered that the "Monarch" is essentially a cable-repairing vessel and is only equipped with the necessary picking-up gear; and in consequence the cable had to be paid out over the bow sheave. The experience gained during the laying of the Anglo-French and Anglo-Belgian cables warranted the assumption that the ordinary equipment of a cable-repairing vessel was sufficient for any emergency which might arise during the operation of laying. The fact that the laying of this Irish cable was successfully carried out by the "Monarch," notwithstanding the severe and adverse conditions, clearly demonstrates that this type of coil-loaded cable can be handled in the same way as any other type of submarine cable.

The necessity for picking up and relaying a portion of the cable, to which reference has already been made, resulted in some variation and irregularity in the spacing of some of the loading coils; in fact circumstances occurred which would be expected to arise during the course of an ordinary repairing operation. It should be noted, however, that this alteration in the spacing of the loading coils was not accompanied by any appreciable change in the electrical values of the cable. The cable has been working continuously since completion, and the tests indicate that it is in perfect condition.

W. N.

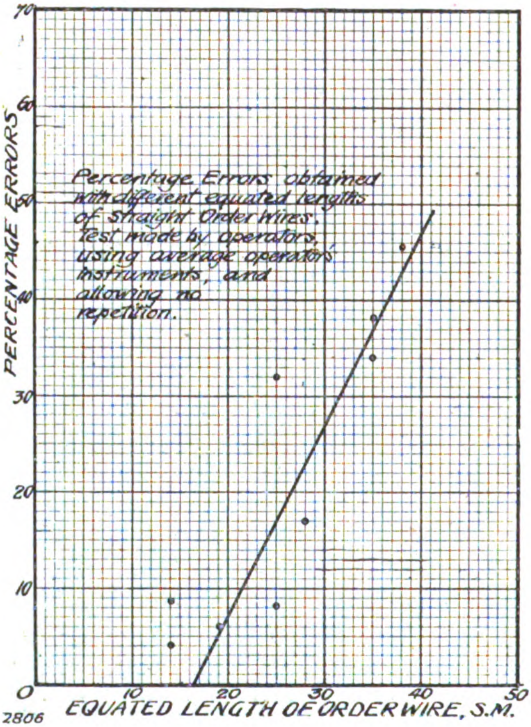
TRANSMISSION RESEARCH WORK: MISCELLANEOUS NOTES.

By Bertram S. Cohen, A.M.I.E.E.

Transmission over Order Wires.—The quality of transmission that it is necessary to give on order wires for satisfactory working merits very careful consideration. It is necessary to realise that the transmission of telephone numbers at a considerable speed over the order wire requires to be of higher quality than that which would suffice for an ordinary local conversation. The first effect observed on a gradual reduction in the audibility of order-wire transmission is an increase in the number of repeats. A decided increase is experienced long before the audibility either by reason of reduction in volume or in articulation has reached a point at which any noticeable effect on an ordinary conversation is to be observed.

In order to obtain the necessary data for the standardisation of order-wire transmission, tests have been carried out, using operators working under conditions approximating as closely as possible to those existing in practice. Each operator read lists of 100 selected numbers to another operator over lines of various equated lengths representing order wires, and an observer checked the sending operator in order to ensure that she gave no wrong numbers. No repeats were allowed. I indicates the percentage errors obtained with different equated lengths of straight order wires. It will be observed that up to an equated length of about 16 s.m. no repeats would be necessary, but that at 21 s.m. 10 per cent. of the orders would require repeating, and this percentage would rapidly increase, until at 40 s.m. 47 per cent. of the orders would be incorrectly received. It is scarcely necessary to mention that beyond a certain point no perceptible improvement would be obtained by repetition, as the reduction in audibility is quite likely to cause the originating operator to fall into error when the " B " operator repeats.

The losses due to a number of " A " operators being on the order wire simultaneously and those due to split order wires now require consideration. With regard to the losses due to a number of " A " operators being on the order wire simultaneously, from figures furnished by the Metropolitan Traffic Department some time ago, it may be taken that the average number of " A " operators simultaneously on a straight order wire would be four. The sending loss due to four operators' instruments is about 8·5 s.m. It may, therefore, be concluded that if a negligible percentage error assuming no repeats is required, the straight order wire should not exceed about 16 − 8·5 = 7·5 s.m. in equated length. The case of split order wires is more complex. The effects on the transmission of any one branch due to the remaining branches depends so much on the position, length and type of the components of the network that no universal law can be given. It is, of course, always possible to calculate the equated length of any one branch by allowing for the



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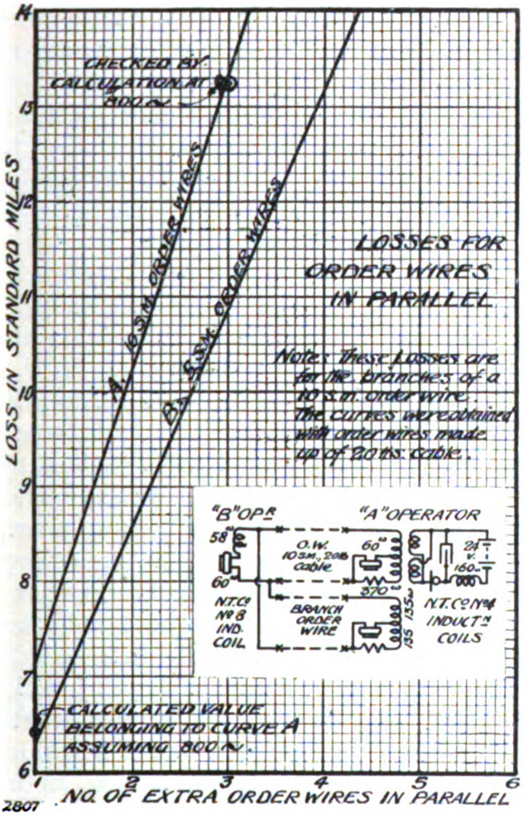
effects of the sending end impedances of the remaining branches at their points of junction.

A very general case is that where the order wires are grouped at the incoming exchange, and **2** with curves and diagrams gives the allowances to be made for certain specific cases. In these curves it is assumed that the equated length of an order wire consisting of 10 s.m. in cable is desired, when other branch order wires of either 5 s.m. or 10 s.m. are connected at the incoming exchange. An example of the use of this curve will now be given. The equated length of an order wire of 10 s.m. of cable, with two 5 s.m. branches in parallel at the "B" end, will be 10 s.m. + 8·6 s.m. = 18·6 s.m. If with three branches of 10 s.m. each, it would be 10 s.m. + 13·3 = 23·3 s.m. These curves were obtained by standard cable measurement and agree with the calculated values. If the "A" operators are not on the branches, the allowance for the branch is reduced somewhat. When the necessary allowance is made for the number of "A"



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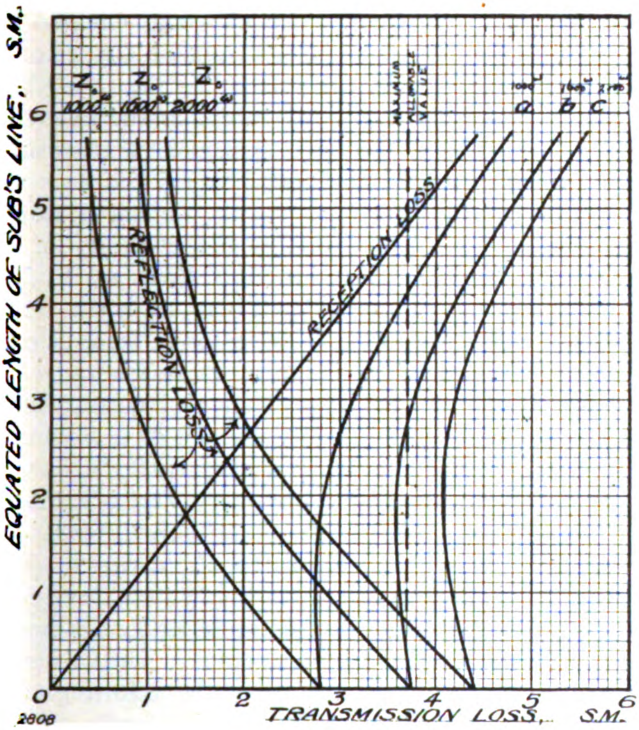
operators on each branch simultaneously, and the percentage errors due to this total equated length is obtained from 1, it will be seen that order-wire grouping is a matter which requires very careful consideration from the transmission standpoint.

The Loading of Short Lines.—Owing to the special conditions existing in this country prior to the transfer, a great deal of investigation, particularly in connection with transmission, has been carried out along lines which an administration with undivided control would find unnecessary. In some cases, however, notably the loading of short lengths of cable line, information of considerable interest and of practical application for special cases has been obtained. According to the agreement that existed between the Department and the National Telephone Company, the maximum equated lengths of the lines from the subscribers' offices to the trunk exchange were specified, and in many cases the existing trunk junctions, consisting of comparatively short lengths of cable, required improving in transmission by a small amount. It has been found that a small increase in volume can be obtained by placing a single load in the centre of the line. Thus, a coil of ·1 henry inductance and 7 ohms effective resistance at 800∼, when placed at the centre of four standard miles of 20 lb. low-capacity cable terminated with an instrument having an impedance of $1060/\underline{60^{\circ}}$ at one end and a long unloaded line of 20-lb. cable at the other end, was reduced to 2 s.m. when talking in one direction and to 1·6 s.m. in the other direction. Such a method of improvement is, however, unsatisfactory, as the single load will to some extent degrade instead of improve the articulation. By using, however, two coils in a short line consistent improvement in volume and articulation can be obtained, and the usual loading formulæ can be adopted. The following example may prove of interest: Trunk junction four miles of 20-lb. low capacity cable having an equated length of 4 s.m., terminated at one end by a subscriber's line of 2 s.m. in 20-lb. cable and with a primary battery instrument having an impedance of $1060/\underline{60^{\circ}}$, and terminated at the other end by twenty miles of open wire 100-lb. copper followed by 20 s.m. of 20-lb. cable, which combination was used to approximately represent a trunk line. Two loading coils, with an effective inductance and resistance of ·1 henry and 7 ohms respectively, were inserted in the 4 s.m. trunk junction, and this line was thereby reduced to about 2 s.m., which agrees well with the result obtained by calculation.

Transmission Losses in Private Branch Exchanges working through Loaded Junction Lines.—In standardising the transmission of a given exchange area where loaded junctions exist, it is necessary to deal with P.B. exchange lines, or, indeed, any apparatus introducing transmission losses, with special care, particularly in cases where no terminal reflection-reducing devices are in operation.

Assume standard C.B. instruments and circuits are in use. By combining local line curves (**12** and **13**) with reflection loss curves (**16**) given in my paper on "Standard Cable Measurements" (POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, April, 1913), some important and interesting results will be obtained.

3 shows such a combination. The reception losses of various equated lengths of subscribers' lines in either 10 lb. or 20 lb. cable are plotted, and, in addition, three curves giving the corresponding reflection losses when such lines are connected to loaded junction lines of either 1000, 1600, or 2000 ohms characteristic impedance. It will at once be noticed that the resultant curves are practically vertical and are actually re-entrant. The practical application of this is somewhat remarkable. Take a case where the maximum allowable subscribers' line is to be 300 ohms in, say, 10-lb. cable. This represents 1·7 miles of cable having an equated length of 2·8 s.m. From the curves plotted in **3**, it will be noted that the receiving loss for this line is 2·1 s.m., or rather less than the equated



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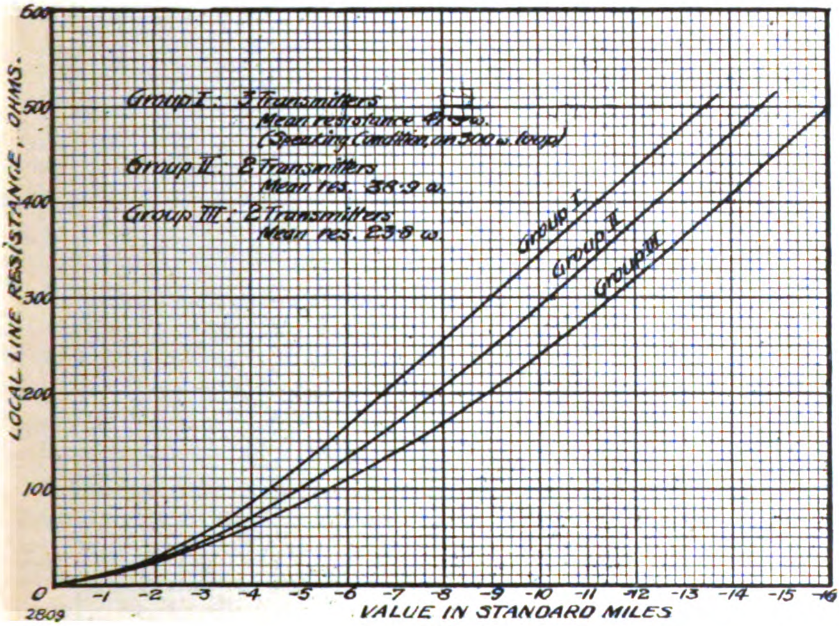
length (see POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, April, 1913, p. 15). Suppose that the heaviest loaded junction line to which this local line may be connected has a characteristic impedance of, say, 1600 ohms, then the reflection loss of the length of local line under consideration will be 1·6 s.m., and the addition of the receiving and reflection losses gives 2·1 + 1·6 = 3·7 s.m. This value is plotted as a dotted vertical line in **3**. Now, in the ordinary way, if this is the maximum allowable value, any extra losses due to P.B. exchanges or extra apparatus in exchange circuits must be compensated for by a reduction in the allowable equated length of the local line, either by increasing the weight of copper or reducing the allowable length, but it will be noted that this dotted line limit is so close to the curve for combined receiving and reflection losses marked (*b*) that we arrive at the important result *that no alteration in type or length of local line will compensate for any additional apparatus loss of even such a small amount as ·5 s.m.* This is a point worthy of serious consideration, and indicates the necessity of adopting reflection-reducing devices where junction lines are loaded. The reception loss is the only one considered here, as it will be found on examination that this is the controlling factor in these cases.

SOLID-BACK TRANSMITTER RESISTANCE.—There is a fairly definite relationship between the resistance of a solid-back transmitter and its volume efficiency, and the result of a research in this direction which was undertaken in connection with the determination of local line values may prove of interest. The resistance values were obtained with various local line conditions and whilst the transmitters were spoken into in a uniform tone. It was found that all the transmitters tested, with one exception which can be taken as abnormal, increased regularly in resistance as the feeding current decreased with increase in the loop resistance. The values for seven transmitters on 300-ohm loops are given in the following table :

Transmitter.	Resistance on 300-ohm loop 22v.		Mean group resistance.
a	49·8	1	47·3
b	46·5		
c	45·7		
d	40·8	2	38·9
e	37·0		
f	23·7	3	23·8
g	24·0		

These transmitters were divided into three groups of similar resistance instruments, as indicated in the table, and the local line sending value plotted for each group ; **4** is the result. It will be observed that the highest resistance transmitters change least in efficiency as the loop resistance increases, the difference between the three groups being of the order of 1 s.m. for local line resistances of 200 ohms upwards. The values plotted were obtained with local lines of all types, 10 lb. and 20 lb. cable and ohmic resistance. The transmitters were all of the same type. A batch of 50 C.B. solid-back transmitters of a particular pattern recently tested give some further interesting results demonstrating the relationship between resistance and volume efficiency. The 50 transmitters were divided into six groups *a* to *f* in accordance with their volume efficiencies as shown on **5**. The mean volume allowance and the mean speaking resistance, both on 300-ohm loops, were plotted for each of the six batches, and it will be observed that the values lie regularly on a curve.



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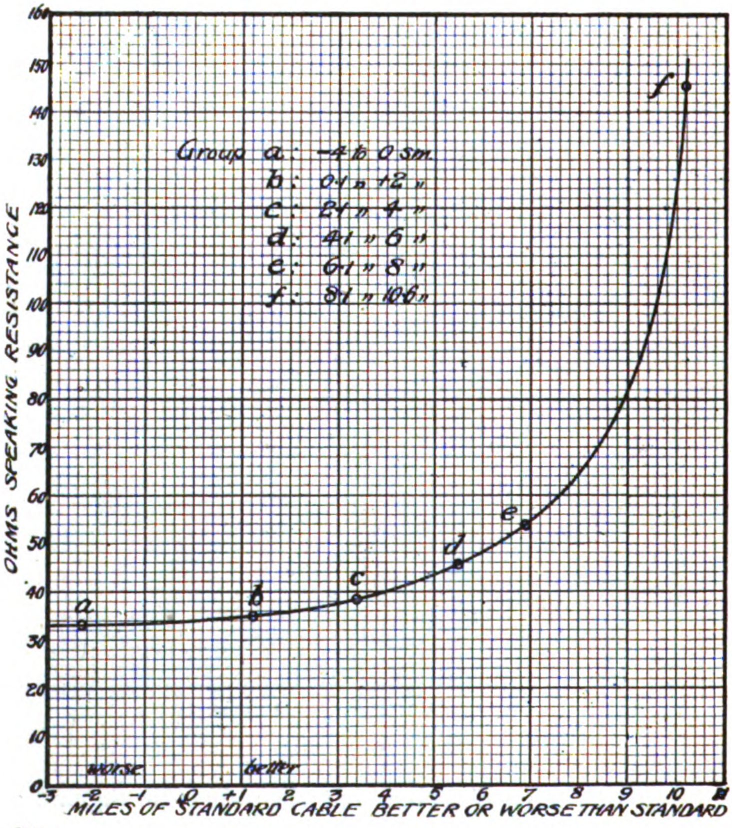
If the transmitter resistance were pushed up further, using the same pattern of transmitter, it can be assumed that the curve would begin to turn back, *i. e.* the volume of efficiency would decrease.

Although **4** and **5** are of interest as demonstrating the fact that a local line curve may be regarded as a characteristic curve for the transmitters used, further data is required before such curves can be utilised to express the volume efficiency of any type of transmitter in terms of its resistance.

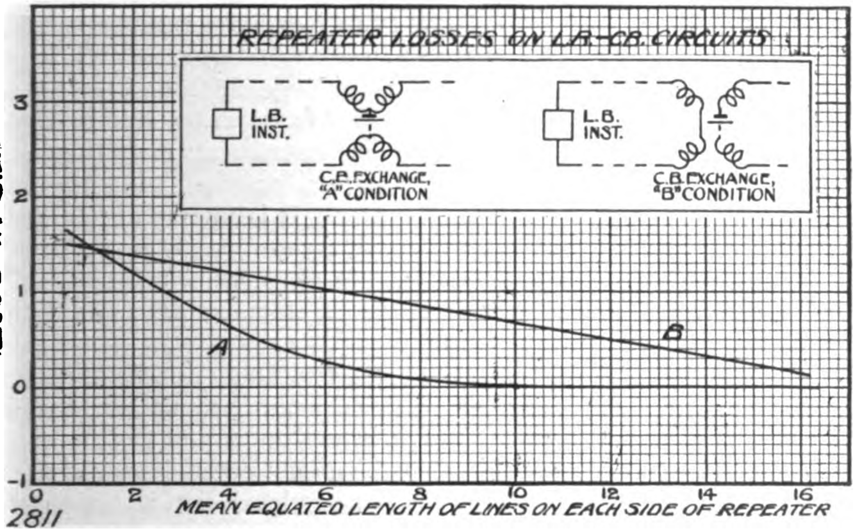
LOSSES DUE TO INTERMEDIATE EXCHANGES.—The losses due to an intermediate No. 1 C.B. exchange "B" operator's circuit between two other No. 1 C.B. exchanges do not appreciably vary with the position of the intermediate exchange with respect to the junction lines on each side of it. The loss with a toroidal repeater can be taken as 0·7 s.m. The introduction of a long line equipment to enable the supervisory signals to be actuated properly when the junctions are long, causes a further loss of 1·5 s.m. This loss is for an equipment consisting of a double wound 75 ohm + 75 ohm relay with windings inserted in series in the lines, each winding shunted by a 2-mfd. condenser and a 600-ohm bridging coil across the line. The series apparatus is responsible for 0·8 s.m. of this loss and the remainder is due to the bridging coil.



5.

When the C.B. exchange is intermediate to another C.B. and to a local battery exchange, the loss will be found to vary with the location of the intermediate exchange. Curve **6** shows this variation for an intermediate exchange with toroidal repeaters. The mean standard mileages of the lines on each side of the intermediate exchange are plotted against the loss. It will be noted that the loss increases as the lines decrease and is almost negligible with a mean mileage of 14 s.m. These losses vary slightly according to the direction of transmission, and the values given are the mean of those obtained in both directions. The curves can be taken to apply to all cases where the equated length of line on one side of the intermediate exchange does not exceed the equated length of the line on the other side by more than 50 per cent.

Two curves are given, A for the losses when the "A" cord circuit is used at the intermediate C.B. exchange. In this case the L.B. instrument is polarised, *i. e.* joined up so that the C.B. current circulates in the L.B. receiver so as to assist the magnetism. This will tend to improve the L.B. instrument reception efficiency, and this improvement is allowed for and eliminated from the result plotted in the curve. This curve will therefore also apply to the case where special apparatus is employed at the L.B. exchange to prevent current circulating in the instrument, provided that the additional loss due to such apparatus is allowed for. In the case of Curve B, this is for the "B" cord circuit at the intermediate exchange, and no C.B. current will flow through the L.B. instrument. The writer would like here to draw attention to the misuse of the term "primary battery" in connection with telephone instruments and exchanges. This is an unsatisfactory designation, as the logical term is undoubtedly "local battery" as opposed to common or central battery, and the letters "P.B." are in general use to designate "Private Branch."



6.

There have also been cases where primary cells were used for the common battery, and other cases where secondary cells were used at the subscribers' instruments.

THE ALLOWANCES FOR "A" AND "B" CORD CIRCUITS IN NO. 1 C.B. EXCHANGES.—It may be of interest to mention here that the ordinary "A" operator's cord circuit on a No. 1 C.B. exchange and using toroidal repeater differs from the standard transmission circuit only in the arrangement of the repeater and the fact that two supervisory signals are used. The former difference does not appear to affect the losses, but the latter adds 0·5 s.m. Again, the "B" cord circuit, using a 12,000-ohm + 27-ohm relay at the centre of the repeating coil shunted by a 2 mfd. condenser, is worse than the standard transmission circuit by 0·5 s.m., so that in an ordinary No. 1 C.B. local junction connection there is always 1 s.m. loss due to extra apparatus.

In some cases it has been the practice to reverse the "B" end repeater when intermediate to a local battery exchange in order to prevent the dropping of indicators by inductive kicks, and in some cases to prevent false rings on party line instruments from the same cause. The transmission loss is, however, increased to 2·5 s.m. in the case of the toroidal pattern repeater. It is interesting to note that the No. 12 type of repeater, which is considerably less efficient than the toroidal repeater when used in the normal manner, lends itself better to this reversing method of stopping inductive kicks and gives a loss when so reversed of only 1·2 s.m.

THE EFFECT OF LOCAL LOSSES ON THE OVER-ALL EFFICIENCY OF LONG-DISTANCE TALKS.—It will be evident from a consideration of the transmission losses given in these notes and the notes in vol. 6, part 1, that the over-all talking efficiency depends to a striking extent on the losses in the various local circuits employed and in the terminal instruments and apparatus, quite apart from the attenuation due to the trunk and junction lines.

To render this perfectly clear, take a typical case which can occur at any time on a trunk connection between two subscribers in any large town in the United Kingdom. The case selected at random is that of an actual subscriber "A" in London with a large C.B. multiple board private branch exchange and a subscriber "B" in a moderate-sized provincial town, also with a similar type of private branch exchange.

The losses in the case of subscriber "A" are tabulated below:

Subscriber "A": Sending Losses.

Resistance of exchange line	270 ohms
,, of extension line	100 ,,
,, of P.B.X. apparatus	66 ,,
Total	436 ,,

Sending loss for this resistance from local line curve	13·4 s.m.
Loss in P.B.X. apparatus	2·7 ,,
Total sending loss . .	16·1 ,,

Subscriber "A": Receiving Losses.

Equated length of extension + exchange lines	3·5 s.m.
Receiving loss from local line curve	2·6 ,,
Loss in apparatus	1·7 ,,
Total receiving loss . .	4·3 ,,

To both these figures must be added the following losses, which are independent of sending or receiving:

Wiring loss at main exchange	0·6 s.m.
Cord circuit loss	0·5 ,,
Trunk exchange loss, London	2·0 ,,
Total	3·1 ,,

This makes—

Subscriber " A " over-all sending loss .	20·2 s.m.
,, ,, ,, receiving loss .	7·4 ,,

Now taking the case of Subscriber " B " in a provincial town with a similar type of private branch exchange.

Subscriber " B ": Sending Losses.

Total resistance of line and apparatus . .	350 ohms
Sending loss from local line curve . . .	11·4 s.m.
Loss in apparatus	2·7 ,,
Total sending loss .	14·1 ,,

Subscriber " B ": Receiving Losses.

Equated length of line	2·7 s.m.
Receiving loss from local line curve . .	2·0 s.m.
Loss in apparatus	1·7 ,,
Total receiving loss . .	3·7 ,,

Wiring loss at main exchange	0·4 s.m.
Cord circuit losses	0·5 ,,
Trunk exchange loss	1·0 ,,
Total	1·9 ,,

This makes—

Subscriber "B" over-all sending loss	16·0 s.m.
,, ,, ,, receiving loss	5·6 ,,

The combined losses sending from "A" and receiving at "B" will be 20·2 + 5·6 = 25·8 s.m., and in the reverse direction 16·0 + 7·4 = 23·4 s.m. To ensure commercial transmission between these two subscribers it is therefore necessary to see that the total remaining losses, including the equated lengths of the trunk and junction lines, does not amount to more than about 20 s.m. In other words a good 56 per cent. of the available transmission is used up in the subscribers' apparatus and lines and in the local exchange quite irrespective of the losses in the junction and trunk lines.

It should be borne in mind that these are distinctly normal subscribers' conditions and that no allowance is made for any ageing effect on the efficiency of the subscribers' instruments, which are assumed to be equal to the standard both for sending and receiving; nor do the cases taken include intermediate exchanges or cases where any extra apparatus, such as long-distance signalling equipment, etc., is inserted. Figures such as these should render it unnecessary to emphasize the importance of keeping the losses in the subscribers' instruments and in the exchanges, both private branch, local, and trunk, down to the absolute minimum.

THE TELEPHONE CABLE EQUIPMENT OF LARGE BUILDINGS.

By F. G. C. Baldwin.

Very little information has been published regarding the cable equipment of large buildings, probably because it is only of late years that the proprietors of such buildings have recognised the importance of a complete telephone installation.

In order that the most efficient and economical cable system may be evolved, it is necessary that each case should receive very careful investigation and be dealt with according to its own particular merits.

Two main classes of telephone service have usually to be provided:

(*a*) private branch exchange service, for hotels, stores, factories, large works; (*b*) local exchange service, where the occupants of buildings comprising blocks of offices, suites of chambers and apartments, markets, require independent connection to the local exchange. Features of a distinctly different type are presented in these two classes.

The chief difficulties in the design of a system are: (1) The short time usually afforded for the execution of the work, and (2) the absence of reliable information as to the probable future requirements. The first of these tends towards an undue haste in carrying out the necessary preliminary surveys and in the work of installation. To meet these difficulties the telephone requirements should be ascertained in the early stages of the building operations, and by a careful study of the growth of telephones in buildings of similar class, due regard being given to the probable requirements of the building under consideration. For a building which is to be wholly served by a private branch exchange, the future as well as the initial requirements are controlled by the proprietors, and usually fairly accurate information can be obtained from them. In buildings requiring a number of independent services, however, the ultimate requirements are difficult to determine.

In providing for a building of the office class the following are the types of line which must receive consideration:

(*a*) Direct exchange lines.

(*b*) Exchange extension lines, internal.

(*c*) Exchange extension lines, external.

(*d*) Private lines, all classes (including fire-alarms, time service lines, etc.).

(*e*) Power lines.

(*f*) Ringing lines.

In ordinary cases it is customary to count all lines other than direct exchange lines as "miscellaneous," the latter being usually few in number as compared with the direct exchange lines, and in making a development study for such cases it is usually sufficient to add a certain percentage of the estimated direct exchange lines to cover provision for "miscellaneous" circuits. The percentage to be added should be determined carefully, as in some cases, such as buildings in large commercial and financial centres, the miscellaneous requirements may be considerable. In London, for example, the number of miscellaneous circuits (not including internal extension lines), is sometimes considerably in excess of the number of direct exchange lines.

With the exception of large private branch exchange installations, internal extension lines can as a rule be provided independent of the cable system proper, as and when required. Special difficulties arise in connection with the provision of party lines, time service lines, power and ringing lines, as more than one subscriber may be served from a circuit and "grouping" is therefore permissible, and the economical arrangement thereof requires serious consideration.

The telephone demands of a building occupied by one firm and served wholly by a private branch exchange do not vary very materially, but the same is by no means true of a suite of offices or building of a like nature where fluctuations in the demand for telephone service are frequently taking place between very wide limits, and must be suitably arranged for. To provide the latter type of service is perhaps a more difficult matter than might appear at first sight.

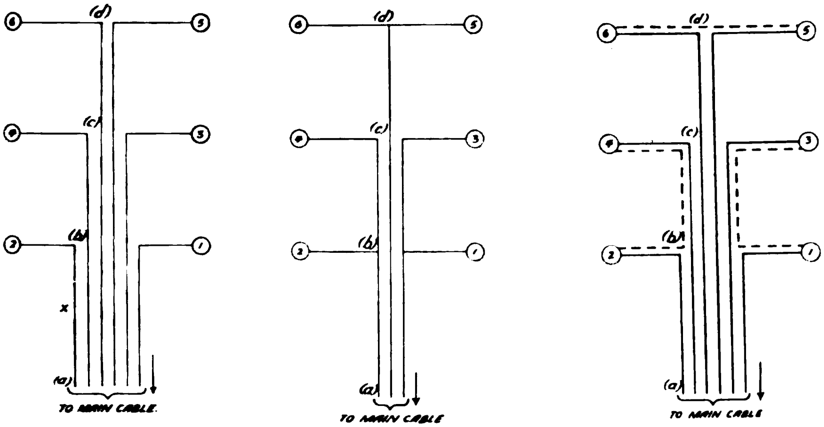
Several different methods of cable distribution are in existence, and a description of some of these may be useful. Owing to the height of buildings it is convenient that distribution should be arranged vertically, generally from the basement or ground floor upwards, and in the examples given the distribution has been carried out in this manner. It should be explained that in the following diagrams (see **1** to **6**) the circles represent distributing points, and each of the straight lines represents a group of pairs of wires connected to a distributing point, but not necessarily separate cables. The points numbered 1 and 2 are on the lowest floor, 3 and 4 on the next, and 5 and 6 on the floor above.

1 illustrates simple distribution, where a number of pairs are led from the street cable direct to distributing points, suitably terminated and left for connection to the subscribers' telephones as required. This arrangement is not flexible, as pairs of conductors terminated at any of the points 1, 2, 3, 4, 5, or 6 are solely available at that particular point, and when all the wires at one of these points have been appropriated relief can be afforded only by a redistribution of the pairs.

The second case (**2**) illustrates the use of "teed" or, as the Americans term them, "bridged" pairs, in affording flexibility. It does not necessarily follow that the whole of the pairs from each point are teed, as only a number of them may be so dealt with, the remainder being connected direct as in **1**.

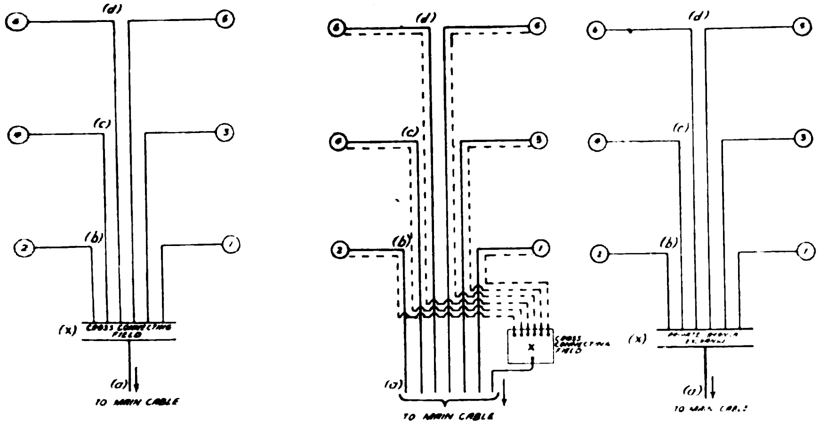
In **3** the use of "interconnected" or "linked" pairs is illustrated. In addition to the pairs connected from each distributing point to the exchange, certain other pairs are provided between one distributing point and another. These pairs may be utilised for internal extension lines, or for connection to the exchange from one distributing point *viâ* another when the spare pairs in the former have been exhausted, or for grouping subscribers on a party line, power, ringing or time service line.

The system illustrated in **4** provides the maximum amount of flexibility obtainable, but this is not always necessary or desirable. The essential difference between 4 and 1 is the introduction of a cross connecting field at point *x*. The whole of the circuits from the street cable and from the several distributing points are, therefore, available for cross-connection at that point.



1. 2. 3.

1.—Simple Distribution. 2.—Teed (or Bridged) Pairs.
3.—Interconnected (or Linked) Pairs.



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4. 5. 6.

4.—Main Cross Connecting Field. 5.—Main Cross Connecting Field.
6.—Simple Distribution for Private Branch Exchange.

Generally a certain number of pairs are required to pass direct from the street cable to the various distributing points, and these need not necessarily be carried through the cross-connecting field, see **5**. The proportion of intercepted pairs provided depends upon the degree of flexibility required, which, of course, varies for different buildings. The number of pairs connected from the main cable system to the cross-connecting field is less than the aggregate number of pairs connected therefrom to the distributing points.

The diagram shown in **6** illustrates a typical private branch exchange installation and needs no special comment.

Each of the systems typified in **1** to **5** possesses its own distinctive advantages, and opinions differ as to the best means of securing the necessary flexibility in any system of cabling. Some degree of flexibility is undoubtedly necessary, but it is exceedingly easy to err on the side of giving too much, thereby producing the following disadvantages:

(1) Increased complexity of the distributing system and a greater cost in the preparation and upkeep of the necessary records.

(2) Increased prime cost.

(3) Increased maintenance charges.

(4) Maintenance rendered generally more difficult.

(5) Increased possibility of interruption to the working lines by the occurrence of faults.

Simplicity is a highly desirable and valuable characteristic, and its application to cable systems is worth serious consideration.

In designing a cabling system tracings of the architect's plans of each floor should be obtained, and upon these should be plotted, either individually or in groups, the lines to be provided immediately and the estimated ultimate lines. These may then be arranged in groups conveniently disposed for distribution. The number of lines included in each group depends upon their initial and ultimate density, and upon the configuration and internal decorations of the building. Regard must also be given to the circuit capacity of the standard cable sizes. The positions of the distributing points are then fixed. If the wiring is to be exclusively external, suitable positions for the distributing points must be selected upon the external walls of the building. When decided, the boundaries of the distributing areas (formed in defining the groups of lines), the branch cables, and the positions of the distributing points are marked upon the floor plans, and the distributing points allotted a distinguishing number. **7** is a plan of the third floor of the Hotel Cecil, London, and shows the details mentioned above. The development information as compiled for each area of distribution is given in the rectangle shown against each distributing point, its upper portion being intended for the number of existing lines (*nil* in this case), the second division showing the number of lines initially required, and the lower portion the number of lines to be accommodated at the end of the period being planned for, as determined by the development study. It will be noticed that the ultimate number of circuits required is in this case very little in excess of the initial number to be fitted.

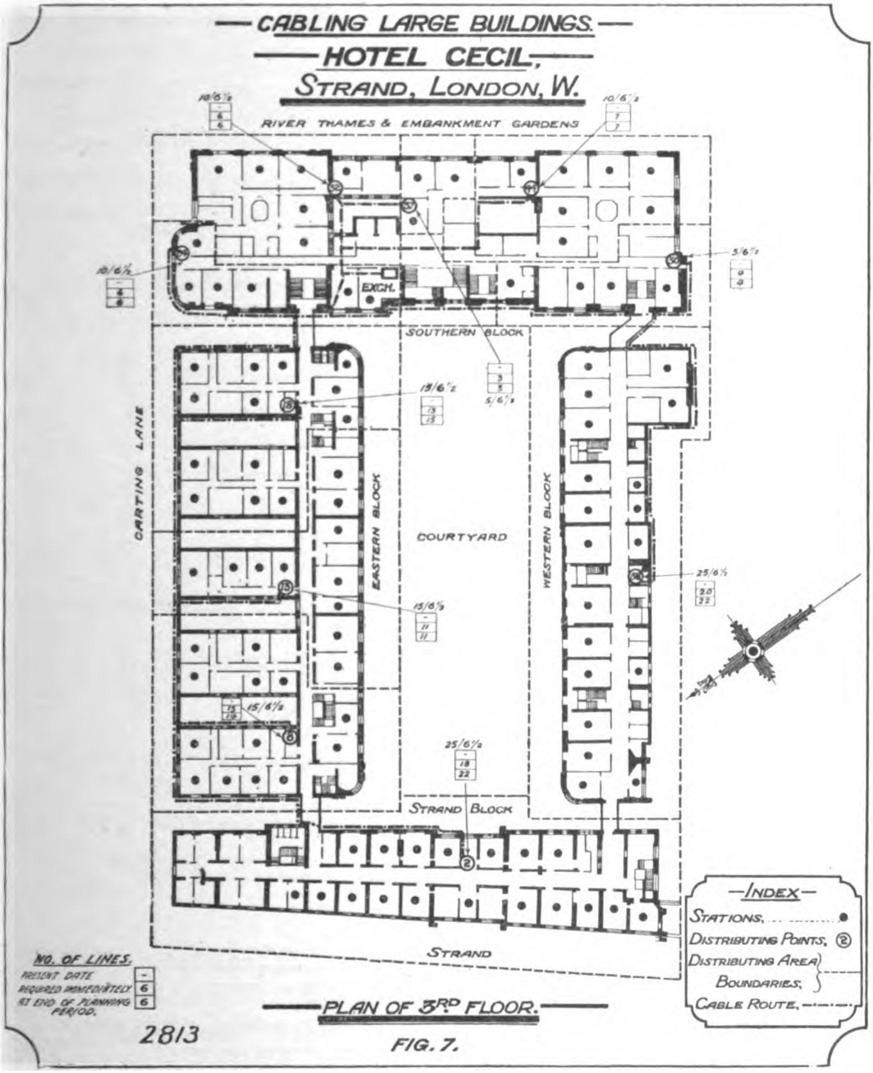
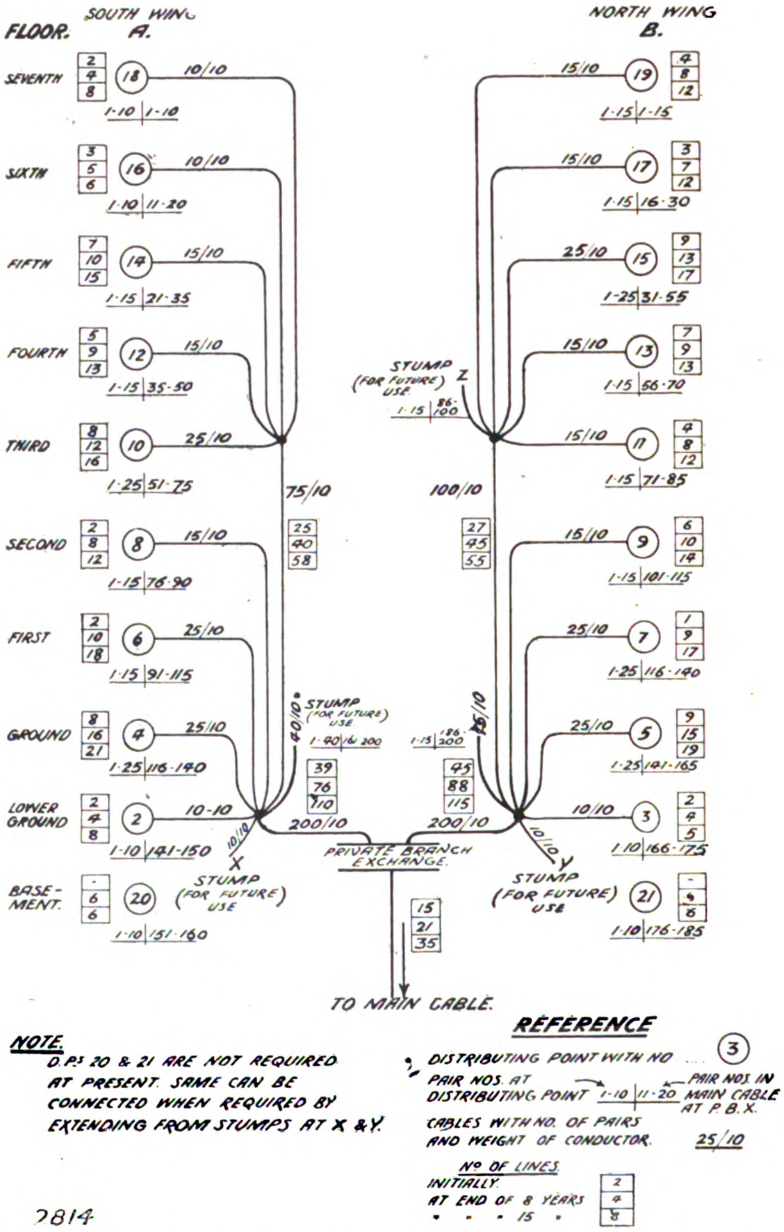


FIG. 7.

The choice of a course for the main cable run, which is to serve the branches to the distributing points, must in a great measure be made during the determination of the positions for the distributing points, as direct and short a route as possible to the private branch exchange or to the street cable, as the case may be, being chosen. A cable distribution diagram is next prepared, being compiled by reference to the various floor plans previously completed. A cable diagram prepared for an installation at "Asiatic House," Great St.

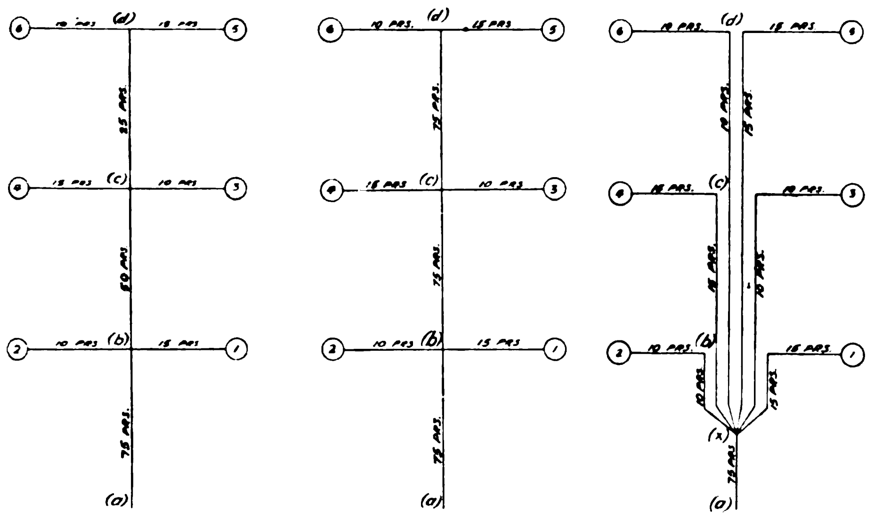

FLOOR.
SOUTH WING A.
NORTH WING B.
SEVENTH 2 4 8 (18) 10/10 1-10 1-10
SIXTH 3 5 6 (16) 10/10 1-10 11-20
FIFTH 7 10 15 (14) 15/10 1-15 21-35
FOURTH 5 9 13 (12) 15/10 1-15 35-50
THIRD 8 12 16 (10) 25/10 1-25 51-75
SECOND 2 8 12 (8) 15/10 1-15 76-90
FIRST 2 10 18 (6) 25/10 1-15 91-115
GROUND 8 16 21 (4) 25/10 1-25 116-140
LOWER GROUND 2 4 8 (2) 10-10 1-10 141-150
BASE-MENT. - 6 6 (20) 1-10 151-160
STUMP (FOR FUTURE) USE X 10/10
75/10 25 40 58
40/10 STUMP (FOR FUTURE) USE 1-40 16 200
39 76 110 200/10
(19) 15/10 4 8 12 1-15 1-15
(17) 15/10 3 7 12 1-15 16-30
(15) 25/10 9 13 17 1-25 31-55
(13) 15/10 7 9 13 1-15 56-70
STUMP (FOR FUTURE) USE Z 1-15 86-100
(11) 15/10 4 8 12 1-15 71-85
100/10 27 45 55
(9) 15/10 6 10 14 1-15 101-115
(7) 25/10 1 9 17 1-25 116-140
75/10 1-15 186-200
(5) 25/10 9 15 19 1-25 141-165
45 88 115 200/10
(3) 10/10 2 4 5 1-10 166-175
10/10 Y STUMP (FOR FUTURE) USE
(21) - 4 6 1-10 176-185
PRIVATE BRANCH EXCHANGE.
15 21 35
TO MAIN CABLE.
REFERENCE
DISTRIBUTING POINT WITH NO (3)
PAIR NOS. AT DISTRIBUTING POINT 1-10 11-20 PAIR NOS. IN MAIN CABLE AT P.B.X.
CABLES WITH NO. OF PAIRS AND WEIGHT OF CONDUCTOR. 25/10
NO OF LINES
INITIALLY 2
AT END OF 8 YEARS 4
" " " 15 " 8
2814

NOTE.
D.P.S 20 & 21 ARE NOT REQUIRED AT PRESENT. SAME CAN BE CONNECTED WHEN REQUIRED BY EXTENDING FROM STUMPS AT X & Y.

8.—Private Branch Exchange for Asiatic Petroleum Company, Great St. Helens, London, E.C. Cable Distribution.

Helens, London, is given in 8, which shows the whole of the cable plant to be installed, the distributing points with their numbers, the number of circuits to be accommodated at each distributing point and in each section of cable initially and at the end of the planned period. The weight of conductor, which is also shown, depends upon the transmission requirements. The preparation of plans and diagrams as outlined above is a feature essential to the satisfactory carrying out of the work, and the foreman should be supplied with copies.

As previously stated, distribution may be conveniently effected by the installation of cables rising at one or more points within or upon the external walls of a building. Branches from these vertical cables may then be terminated at suitable points for distribution.



9. **10.** **11.**

9.—Tapering Single Cable. **10.**—Single Cable without Taper.
11.—Parallel Cables.

The vertical cables may be arranged in one of a number of ways, some of them being exemplified in **9**, **10** and **11**.

9 illustrates the "Taper" system.

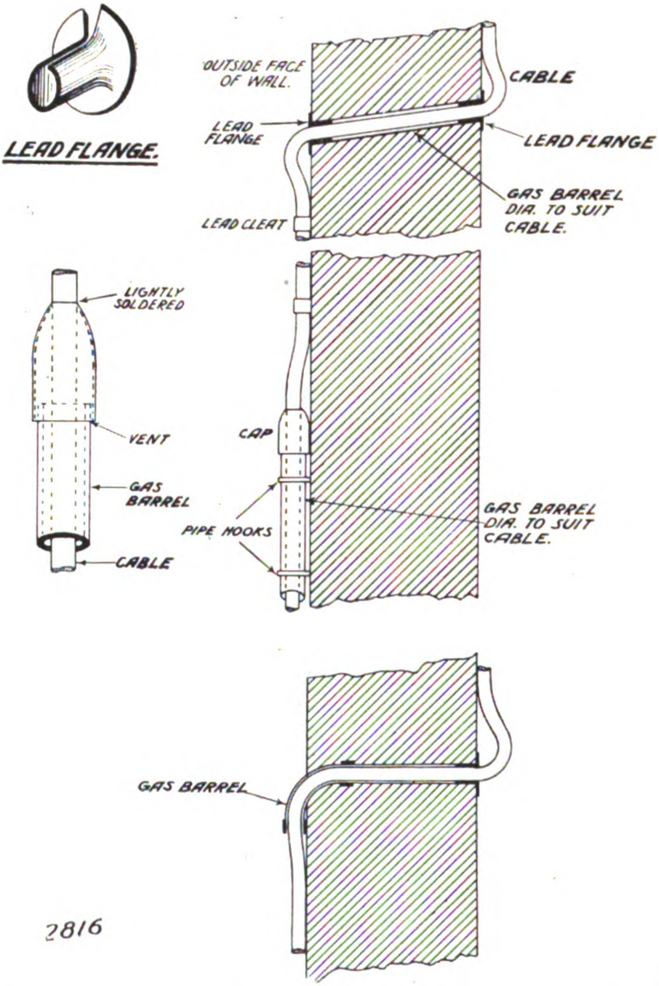
In **10** a single cable of even circuit capacity throughout its length extends as far as the top floor of the building, the branches being tapped off as in the previous system. This method readily lends itself to the provision of teed or interconnected circuits.

In **11** the main feed ends at a suitable point, preferably somewhere near the first branch, and is extended by a number of smaller cables, each serving a particular floor or portion of a floor.

This system lends itself to most cases, and possesses the following advantages over those shown in **9** and **10**:

(*a*) Total number of joints less.

(*b*) Distribution simpler.



12.—Methods of Leading Cables up and into Buildings, etc.

(*c*) The main joint forms a convenient point for re-arrangement of pairs.

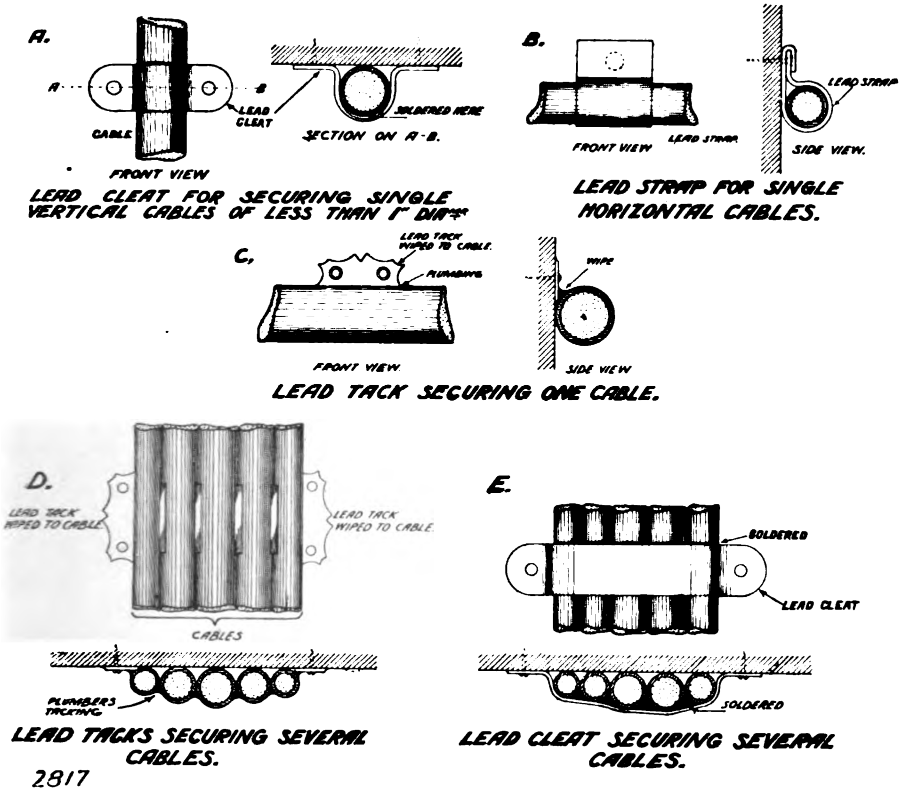
(*d*) The number of different types of cables used is less than in the first system.

(*e*) More readily lends itself to modification without destroying symmetry in cable arrangement.

(*f*) Capital cost less by about 30 per cent., due principally to the saving effected in jointing and its attendant operations, and therefore—

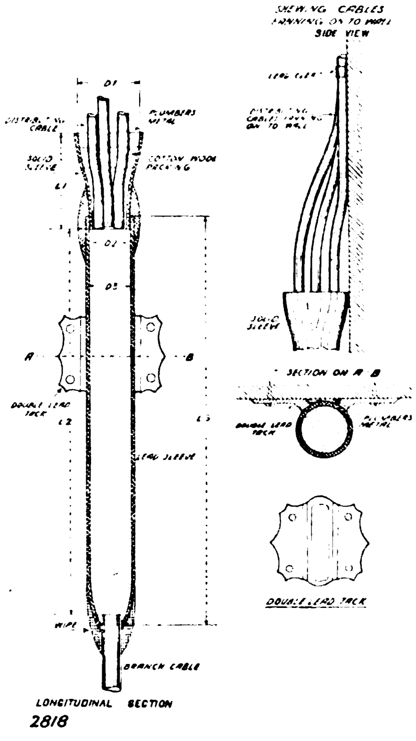
(*g*) Work can be completed more quickly owing to a reduction in the skilled labour required.

Lead-covered cables are now largely used in the cabling of large buildings. Jointing and its attendant operations are already standardised and need not, therefore, be dealt with. The protection of lead cables from mechanical injury is only required in exceptional cases, as, usually, spacious chutes or large chasings accommodating pipes and cables for general purposes can be utilised. Where, however, cables are led up, or along walls in exposed places, or are fixed in other situations where injury is likely to be occasioned, galvanised iron tubing or other suitable coverings should be provided. **12** illustrates a neat and secure method of leading cables up and through walls and into buildings.



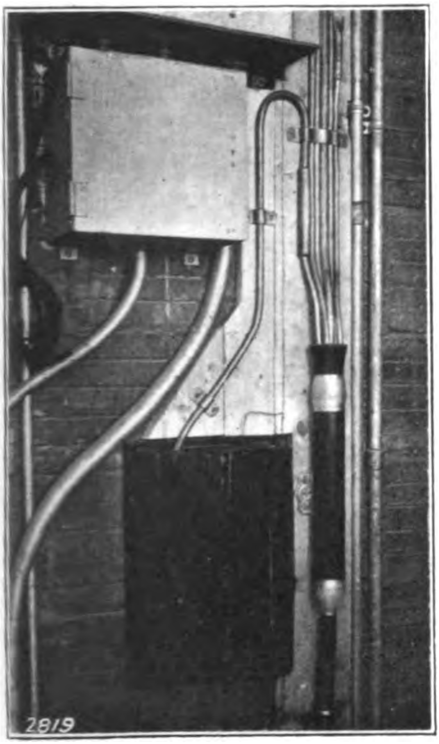
13.—Methods of securing Lead-covered Cables to Flat Surfaces.

Ledges, cornices and other prominences may frequently be utilised for supporting external cables. Some methods of securing lead-covered cables to the plain surfaces of walls, which may be applied to either internal or external cables, are illustrated in **13**. For vertical cables the plumber's lead tacks shown at *C* may advisedly be placed alternately at the opposite sides of the cable. A method of supporting several heavy parallel vertical cables is shown at *D*. The arrangement shown at *E* is suitable for smaller cables, say of 1 in. diameter and under. To prevent the cables slipping they may be soldered to the top of the lead strap. Care is necessary in order to ensure that the weight of the cables is distributed equally throughout the several supports. A suitable spacing for the cleats is 2 ft.

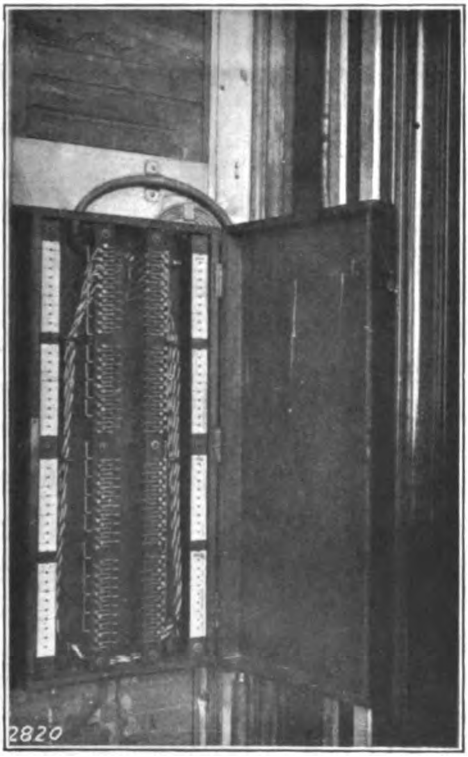


14.—Distributing Joint for P.C. Cables.

For distributing purposes (as in **8** and **11**) it is frequently necessary to connect several small cables to one large cable. A suitable joint for this purpose is illustrated in the drawing reproduced in **14**, which is self-explanatory. These joints have been employed with highly satisfactory results. A prominent feature is the lead collar in which the whole of the distributing cables are symmetrically arranged and secured to form an air-tight joint by flowing in molten plumbers' metal. The collar affords suitable means for plumbing to the lead sleeve of the joint, and provides facilities for the subsequent renewal of the sleeve, in case of necessity, with a minimum disturbance of the existing cables. If it be anticipated that additional cables will be required at a later date, the requisite spare ends or tails may be included in the joint. By means of the joint shown five distributing cables are connected to the single branch cable.



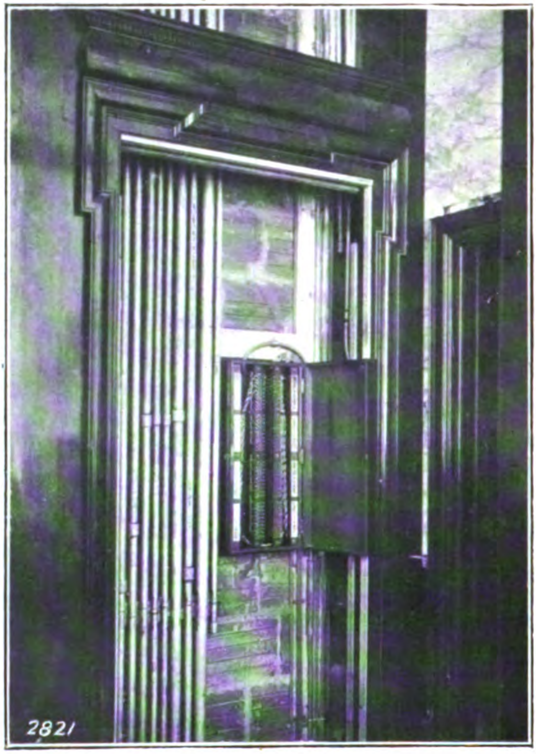
15.—Cable Distribution Joint.



16.—Distribution Case with Cover Open.

15 shows a distributing joint of the above-mentioned type. The distributing cables rising to the upper floors may be seen; one of the distributing cables leads into a distribution case (which forms one of the distributing points for the floor), and a spare tail of cable for future extension is visible on the right-hand side.

Numerous methods and contrivances for terminating paper cables have been devised during the past twenty years, and many of them have been discontinued. The method employed in this country at the present time, involving the use of waxed silk and cotton lead-covered cables, cannot be regarded as entirely satisfactory. The silk and cotton cable requires very great care in handling, and can only be used in situations sheltered from the weather and from a damp atmosphere. Furthermore, silk and cotton insulated cable is expensive. There appears to be a need for a cheap contrivance for terminating the paper-insulated wires without the use of silk and cotton cable, and without the need for a plumbed joint. Experiments in this direction were made in London some time ago. One method tried in an installation consisted in waxing the ends of the paper-insulated wires and connecting them direct to strips of soldering-tabs comprising the distributing point. In a second method the wires were terminated on terminals or tabs passing through the back of a specially constructed box, which was afterwards effectually sealed by flowing in molten wax. These experiments were so far successful as to commend the processes for further development.

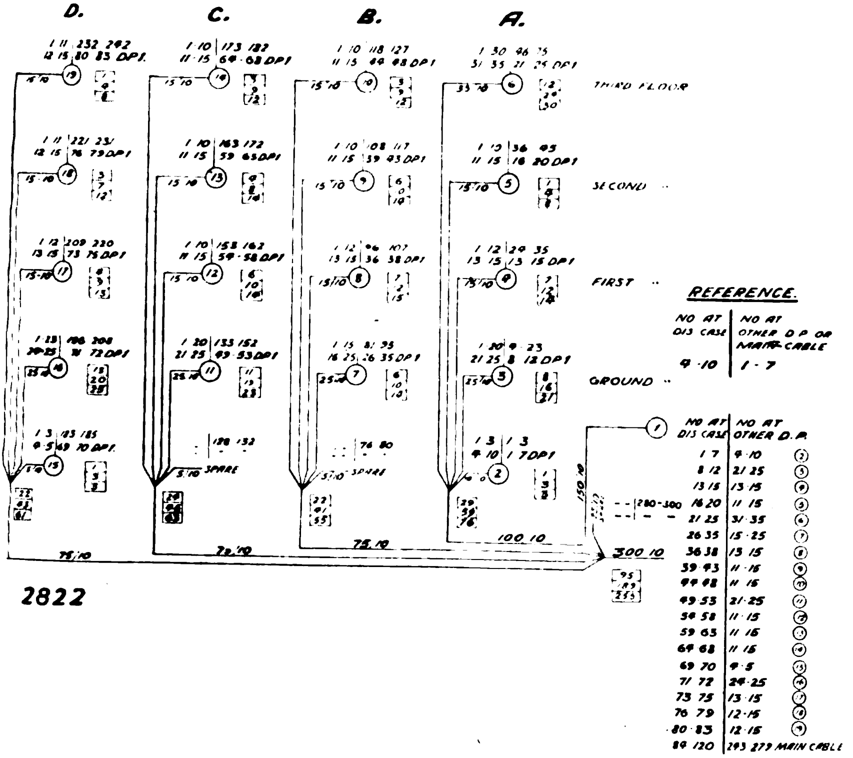


17.—Distribution Case in Chase.

16 is reproduced from a photograph of a distribution case fitted and wired in connection with the cabling system shown in diagram form in **8**. The hinged lid is shown open, and the strips of tabs with cross connecting wires in position can be seen.

17 is a view of the same distribution case, and shows its position in a large chasing provided for the accommodation of pipes and mains of all classes. This chasing is in the form of a recess or cupboard, which extends from top to bottom of the building. Removable covers are fitted at each floor so that easy access is afforded.

18 is a diagram of an actual cabling scheme in which an attempt has been made to obtain flexibility by the provision of a cross con-



18.—Cabling Scheme Diagram.

necting field fitted in the manner shown in 5, as described previously. The manner in which the pairs are distributed is indicated on the diagram by a system of numbering, and the pairs which are available at the cross connecting field (shown as distributing point No. 1) may be readily followed. The cables providing for each of the four wings of the building are shown under *A*, *B*, *C* and *D*, and these cables are concentrated at a distributing joint in the basement, to which is also connected the cable from the cross connecting field. The number of pairs and weight of conductor of each cable is shown, as also the existing number of working circuits and the anticipated development at the end of the eight- and fifteen-year periods. It will be observed that thirty-seven pairs are connected direct from the cross-connecting medium to the street main, and eighty-three pairs are distributed amongst the eighteen distributing points scattered throughout the building.

LONDON-BIRMINGHAM-LIVERPOOL TELEPHONE CABLE.

By W. J. HILYER.

IN consequence of the great growth of telephone traffic between London, Birmingham, and Liverpool, together with the increasing difficulties encountered in obtaining satisfactory routes for new pole lines for long aërial trunks, it has become necessary to provide an underground telephone channel connecting the three cities. The publication at this stage of a few particulars relating to the scheme will probably be of interest.

Stoneware multi-way ducts of 3⅜ in. internal diameter are being used to form the conduits. **1** and **2** show the route followed and the number of conduits laid down for trunk purposes in the various sections. It will be seen from the amount of pipe space for which provision is made that a large increase in the service along the route is anticipated.

At ordinary cable-jointing points—normally 176 yards apart—the scheme provided for F 2 manholes in the 6-way section of the route, F 1 manholes in the 4-way section, and cast iron couplings (excepting through towns, where double junction boxes or carriage-way jointing chambers are required) in the 2- and 3-way sections.

At the points 2½ miles apart where loading coils will be inserted, F 8 and C 8 special manholes are provided between London and Birmingham, and F 1 and C 1 manholes between Birmingham and Liverpool.

The internal dimensions of the manholes named above are as follows:

Type of Manhole.	Length.	Breadth.	Height.
F 1	4′ 3½″	3′ 0″	3′ 0″ or 4′ 0″
F 2	4′ 3½″	3′ 6″	5′ 0″
F 8 (special)	8′ 0″	5′ 6″	6′ 0″
C 1	4′ 0″	3′ 0″	4′ 0″
C 8 (special)	7′ 0″	7′ 0″	6′ 0″

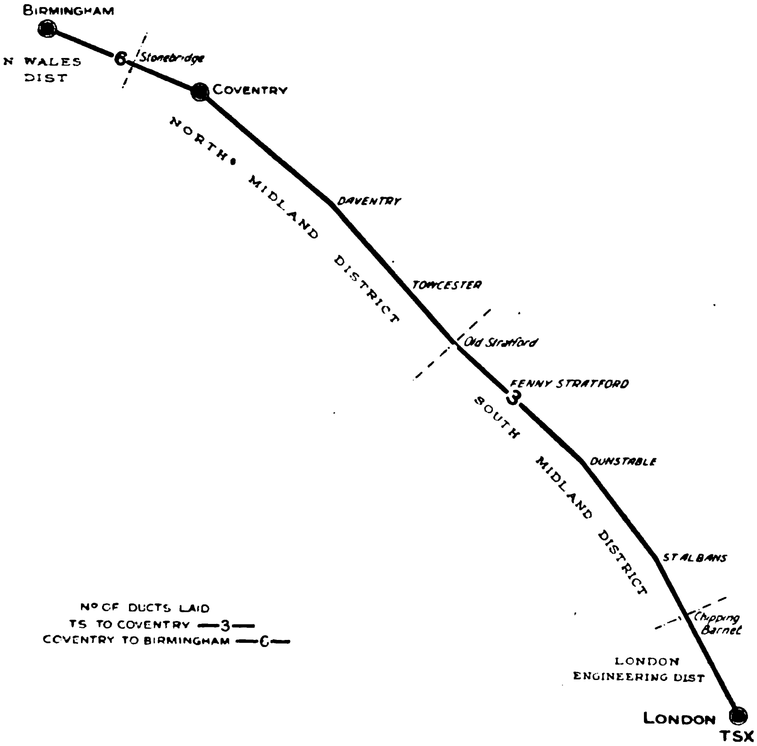
The route length between London and Birmingham is 110½ miles, and between Birmingham and Liverpool 90 miles.

In designing the cable the end in view was to obtain such grades of efficiency as would provide for the following classes of connection:

(*a*) Communication between the telephone areas of the three towns.

(*b*) Communication between the zones of which the towns are zone centres.

(*c*) Long-distance communication, *i. e.* communication between places involving longer trains of connections than those considered under (*a*) and (*b*).

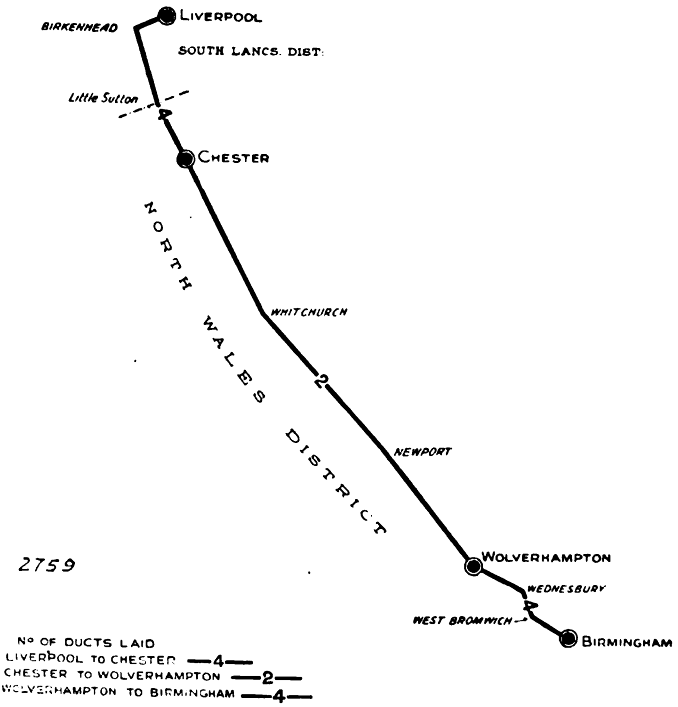


I.—London–Birmingham Route. London–Chipping Barnet, 11·7 miles; Chipping Barnet–Old Stratford, 41·7 miles; Old Stratford–Stonebridge, 46·9 miles; Stonebridge–Birmingham, 10·1 miles.

The air-space paper-core cable ultimately determined upon contains two 300-lb., fourteen 200-lb., twelve 150-lb. and twenty-four 100-lb. loops made up in multiple twin 4-wire core formation—(stock description 4/300 MT, 28/200 MT, 24/150 MT, 48/100 MT). A diagram showing the section (full size) of the cable is given in 3, and the theoretical electrical constants of the circuits are given in Table I.

All the loops will be loaded at the outset, as will also twelve superposed circuits formed on 150-lb. and 200-lb. 4-wire cores.

The coils will be of the Western Electric Company's iron-core pattern. At each loading point the following coils will be inserted: fifty type 535 for the 100-, 150-, and 200-lb. circuits; two type 545 for the 300-lb. circuits; and twelve type 536 for the superposed circuits; the whole of the coils will be contained in one cast iron case. A dimensioned drawing of one of the cases of coils is given in **4** and a photograph of a similar case in **5**. Electrical data relating to the coils are given in Table II.

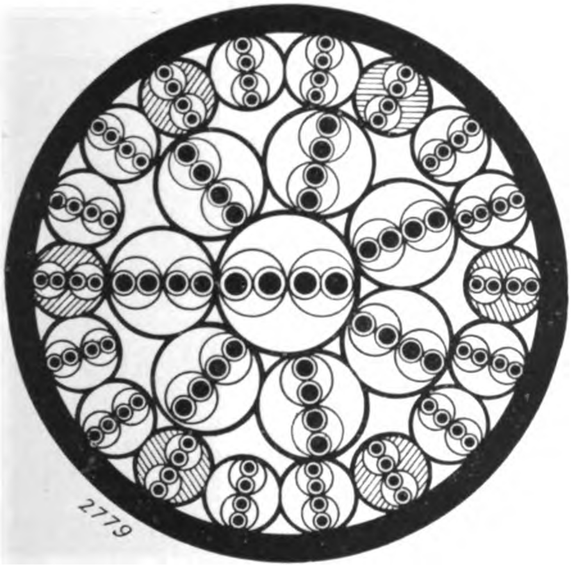


2.—Birmingham–Liverpool Route. Birmingham–Little Sutton, 79·7 miles; Little Sutton–Liverpool, 10·2 miles.

The "leading-out" conductors (for connecting the coils to the main cable) are to be paper-insulated and impregnated, and are contained in two separate cable stubs; one of these will be connected to the "up" side of the main cable and the other to the "down" side. The necessary connection between the side and phantom circuit coils will be made within the case. The paper coverings insulating the leading-out conductors will be coloured; the colour scheme for the cable stubs provides for the identification of the type of coil connected to any pair, and also for the identification of those 4-wire cores in connection with the superposed circuit coils.

The two windings of any coil of types 535 and 545 will be led out on the one side by means of a pair in the one cable stub, and on the other side by means of a pair in the other stub.

Each pair of coils 535 and 545 (and in twelve instances a pair of coils 535 plus a coil 536), which will be inserted in a 4-wire core in the main cable, will be led out on the one side by a 4-wire core in the one stub, and on the other side by a 4-wire core in the other stub. The same colour scheme is to be used for the two stubs, and a pair or core of wires of any particular colour in one stub will be connected through a coil or pair of coils in the case to another similarly coloured pair or core of wires in the other stub.



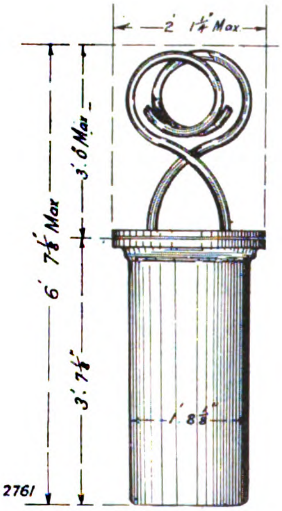
FULL SIZE
CENTRE CORE 300 LBS CONDUCTORS
1ST LAYER 200 LBS "
2ND LAYER {150 LBS " (HATCHED)
100 LBS "

3.

6 shows in diagrammatic form the windings of coils of types 535 and 545 and the manner in which these windings are connected to the conductors in the cable stubs. 7 shows similarly coils of types 535 and 536 connected to form a complete side and superposed circuit unit; it will be seen that in this unit the coils 535 act inductively for currents passing round the side circuits to which they are respectively connected, while coil 536 acts non-inductively for such currents, and also that coil 536 acts inductively and coils 535 non-inductively for currents passing round the superposed

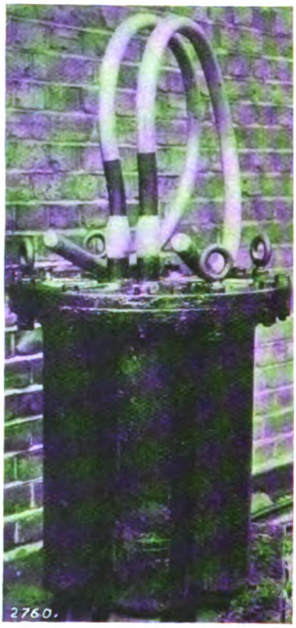
circuit. The coils are wound in sections on the iron cores as indicated in order to prevent as far as possible energy losses and cross-talk.

The pipe line is now completed between London and Birmingham and is nearing completion between Birmingham and Liverpool, and cable-laying is proceeding. The cable for the London-Birmingham section is being manufactured and laid by the Western Electric Company, and that for the Birmingham-Liverpool section by the British Insulated and Helsby Cables, Ltd. The Western Electric Company is providing the loading coils for the whole of the work.



TOTAL WEIGHT COMPLETE (WITH COILS) 1500 LBS.

4.—LOADING COIL CASE.



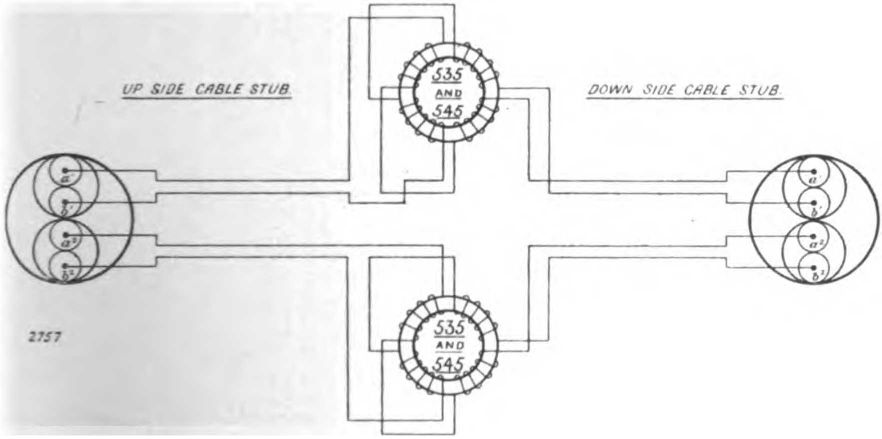
5.—LOADING COIL CASE.

In order to prevent cross-talk between superposed and side circuits special precautions will be taken to joint together such wires and pairs in successive lengths as will secure the electrical balance of the two wires of a side circuit or of the two pairs of a superposed circuit. (*See page 41 et seq.*)

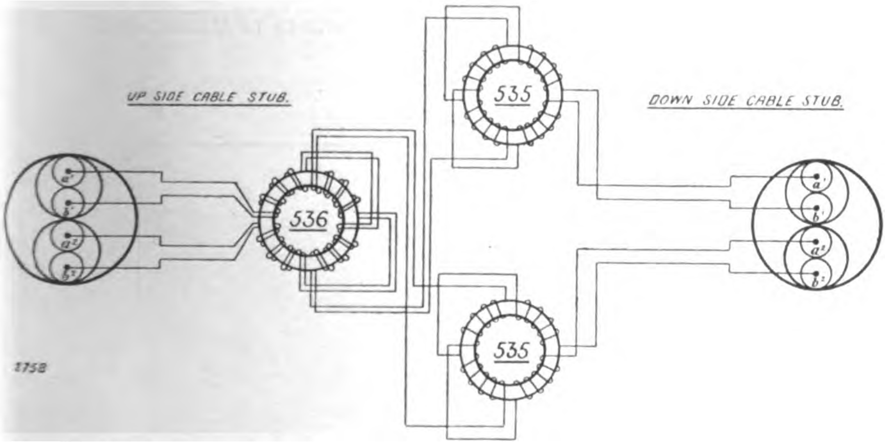
The cases of loading coils will not be placed in the manholes at the loading points, but will be buried horizontally in the ground with the flange of the case and the connecting cable stubs projecting through the wall of the manhole. **8** shows a coil case in position. At each end of the 2½-mile sections air nozzles will be provided in the main cable for desiccating purposes.

As indicated above, the loading spaces are 2½ miles with half spaces at the London and Liverpool ends and on either side of Birmingham.

Table I shows in addition to the electrical constants of the lines the equated lengths for the different gauges. These are such that the services referred to on page 33 are provided by the conductors indicated below.

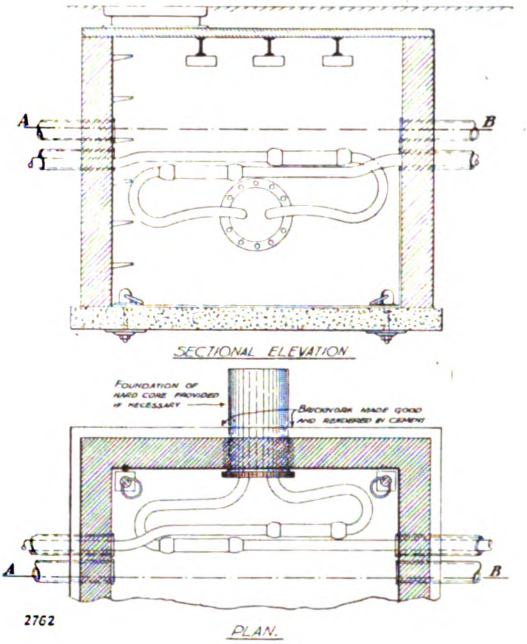


6.—WINDINGS AND CONNECTIONS OF COILS 535 AND 545 FOR ORDINARY CIRCUITS.

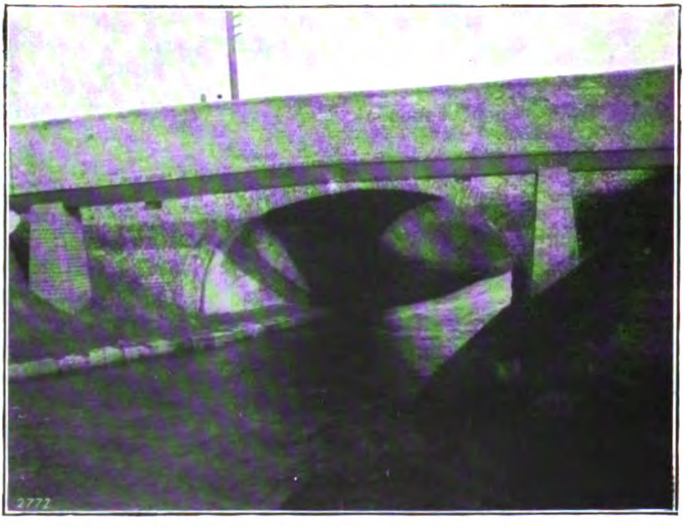


7.—WINDINGS AND CONNECTIONS OF COILS 535 AND 536 FOR SIDE AND SUPERPOSED CIRCUITS.

		Conductors.
Service (*a*)	Between London and Birmingham Between Birmingham and Liverpool	100 lbs.
	Between London and Liverpool	150 lbs. superposed and 200 lbs.


A
B
SECTIONAL ELEVATION
FOUNDATION OF HARD CORE PROVIDED IF NECESSARY
BRICKWORK MADE GOOD AND RENDERED IN CEMENT
A
B
2762
PLAN.

8.—Loading Coil Case in Position and Coils Jointed to Main Cable.



9.—London-Birmingham-Liverpool Telephone Cable. A Point on the Route. Cables carried alongside Stowe Bridge, Weedon.

TABLE I.—*Data Relating to Loaded Loops.*

Weight per mile lbs. (single wire).	Steady current values.		Values when $2\pi n = 5000$.				Equated length (standard miles) of section.		
	Line resistance, ohms per mile loop.	Wire-to-wire capacity. Mfds. per mile.*	Inductance henries per mile.	Attenuation constant per mile.	Wave-length (miles).	Characteristic impedance.	London-B'gham.	B'gham.-L'pool.	London-L'pool.
100	17·56	·065	·055	·01161	21	$922\overline{/2^\circ}$	12·1	9·9	22·0
150	11·71	·070	·055	·00875	20·2	$886\overline{/1^\circ 23'}$	9·1	7·4	16·5
150 (superposed)	5·85	·100	·034	·00759	21·5	$583\overline{/1^\circ 15'}$	7·9	6·4	14·3
200	8·78	·065	·055	·00684	21	$920\overline{/1^\circ 5'}$	7·1	5·8	12·9
200 (superposed)	4·39	·090	·034	·00601	22·7	$615\overline{/1^\circ 1'}$	6·3	5·1	11·4
300	5·85	·065	·055	·00480	21	$920\overline{/0^\circ 42'}$	5·0	4·1	9·1

* Pair-to-pair in the case of superposed circuits.

The insulation resistance between any wire and the remaining wires and earth will not be less than 5000 Ω per mile.

The ratio S/K (leakance/capacity) will not exceed 20 when $2\pi n = 5000$.

		Conductors.
Service (*b*)	Between London and Birmingham	150 lbs.
	Between Birmingham and Liverpool	100 lbs.
	Between London and Liverpool	200 lbs. superposed
Service (*c*)	Between London and Birmingham	200 lbs.
	Between Birmingham and Liverpool	150 lbs. superposed and 200 lbs.
	Between London and Liverpool	300 lbs.

The cable will not be led into any office or testing point between London and Birmingham or between Birmingham and Liverpool. It is anticipated that the whole of the work will be completed and the circuits working by July.

When completed the London–Liverpool circuits will be among the longest of the loaded subterranean telephone lines of the world, and the 300-lbs. circuits will be unique in the fact that the conductors are heavier than those of any subterranean telephone lines hitherto laid in Great Britain.

In concluding I have to thank the Western Electric Company for the drawing and photograph in 4 and 5.

TABLE II.—*Electrical Data relating to Loading Coils.*

Type of coil.	Windings in series.			Maximum electro-static capacity between windings (mfds.).	Minimum insulation resistance. (megohms.)
	Inductance (henries)	Maximum effective resistance at 800 p.p.s. (ohms).	Maximum ohmic resistance.		
535	·135	6·75	3·4	·0035	1000
536	·082	4·10	2·0	·0007	1000
545	·135	4·72	2·6	·0035	1000

The insulation resistance is measured with 100 volts direct between any one winding and all the other windings and the containing case. In this Table the term "winding" includes the leading-out conductors in the cable stubs.

BALANCING OF TELEPHONE CABLES WHICH REQUIRE TO BE LOADED FOR SUPER-IMPOSED WORKING.

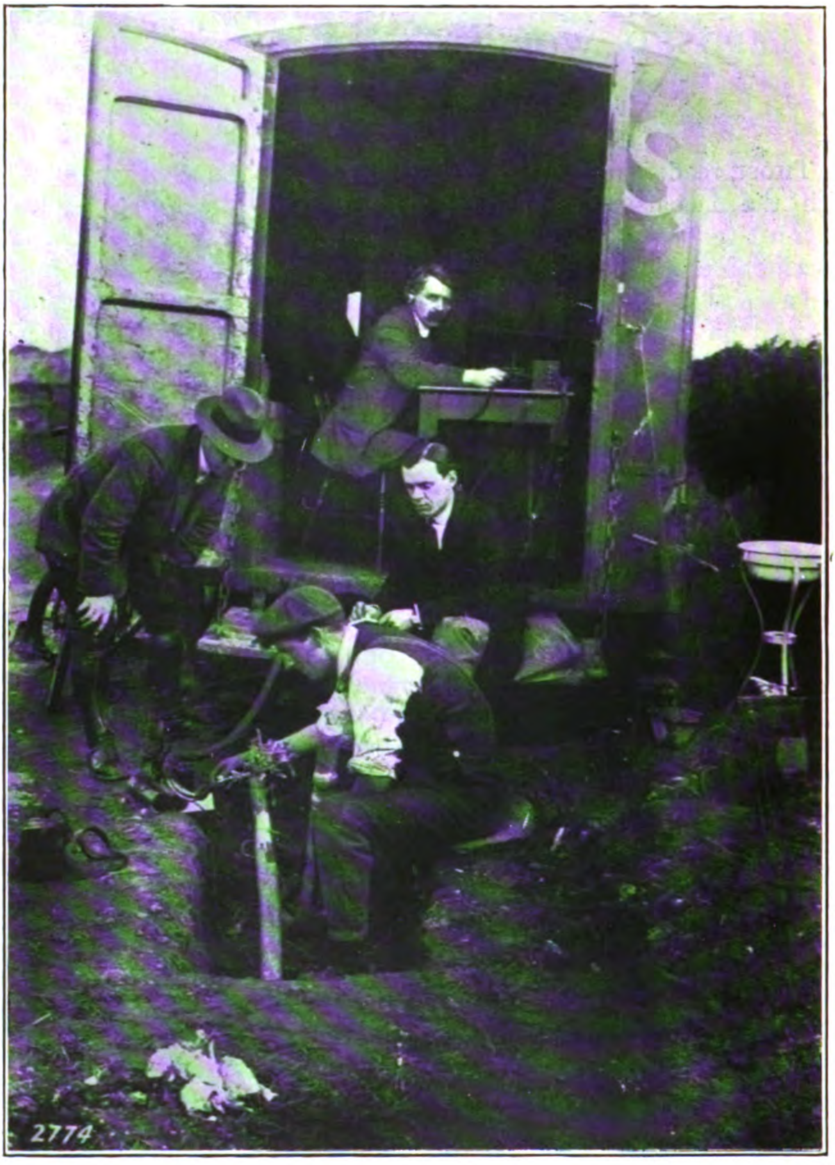
By S. A. Pollock, M.I.E.E.

Those readers of the Journal who are not already acquainted with the Department's method of balancing telephone cables intended to be loaded and superimposed may be interested in a description of the system of testing and selection of wires for jointing, which has resulted in a very high standard of balance being obtained on the new multiple twin cable completed in November last between Leeds and Hull. The first part of this article will be devoted to the simple theory upon which the system of selection is based, and the second part to the results obtainable and some observations upon the organisation of the work on the road.

Since the principle of inserting crosses in telephone lines for the elimination of inductive disturbances has been dealt with in the various technical instructions issued by the Post Office from time to time, I need not recapitulate all that has been published in the matter already, but it may be interesting to refer to the work of Messrs. F. Tremain and A. W. Martin, who investigated in 1900 the causes of cross-talk and disturbances between circuits on the London–Birmingham underground cable immediately after laying. In their joint reports to the Engineer-in-Chief they submitted schedules showing the out-of-balance of capacity resistance and insulation for the various wires in the cable, and the crosses which were put into the wires as the result of these tests. The crosses had the effect of eliminating not only the cross-talk between telephone circuits, but the disturbance previously caused by Wheatstone telegraph circuits in the cable.

The results obtained in this case were doubtless responsible for the introduction of systematic crossing of wires which was required in later published instructions, but the use of multiple twin cable and the adoption of the jointing scheme of colour rotation rendered the scheduling of crosses upon the results of out-of-balance tests unnecessary for this description of cable in the unloaded condition. The extension of loading has, however, revived the necessity for obtaining a better balance than the colour-jointing scheme provides in practice, and this article deals with the latest developments in this direction.

A description of the method may conveniently be divided into:



Testing a Section of the Leeds–Hull Cable. Tent removed to show Cable ends and Testing Leads.

I. CONSIDERATION OF THE CONDITIONS GOVERNING INTERFERENCE BETWEEN THE CIRCUITS.

II. DESCRIPTION OF THE APPARATUS USED AND METHOD OF MEASUREMENT.

III. METHOD OF SELECTING WIRES TO BE JOINED TOGETHER.

I. CONDITIONS GOVERNING INTERFERENCE BETWEEN THE CIRCUITS.

There are three conditions to be considered, viz.:

(1) Interference between side and side circuit.

(2) Interference between side and superimposed circuits.

(3) Interference between both side and superimposed circuits.

(1) *Conditions for no interference between side and side circuit.*—**1** is a diagram of the usual arrangement of circuits connected together for providing a superimposed circuit upon two loops. Considering only electrostatic induction, if an alternating current is flowing in the circuit AB there will be an alternating difference of potential between A and B, and because the two loops are connected together at the middle points of the transformers the wires CD will be intermediate in potential between A and B if the capacities between the wires of the loops are symmetrical. In practice the capacities are not quite symmetrical, and the magnitude of the effect of want of symmetry will depend upon the potential to which the wires are raised by the alternating current. For the same power at any point the potential in loaded circuits is higher than in unloaded circuits whilst the current strength is less. Taking the effects of A and B separately upon C and D, if the capacities W and Z are equal, the charges induced on C and D by A will be equal to each other and will produce no current round the side circuit CD; similarly if the capacities X and Y are equal, the charges induced by B will be equal to each other and will produce no current round the side circuit CD. But these are not the only conditions which give freedom from interference between the two side circuits.

1a gives the superimposing connections in another form, the four wires of one core of a cable being shown in cross section with the capacities between them as before. Taking again a difference of potential between the wires AB and calling it $Va—Vb$, where Va and Vb are the potentials of A and B respectively, we shall find the conditions required in order that there shall be no difference of potential between C and D. Let Vw, Vx, Vy, Vz represent the potential differences between the wires AC, CB, BD, DA respectively, and W, X, Y, Z the corresponding capacities, and let there be no

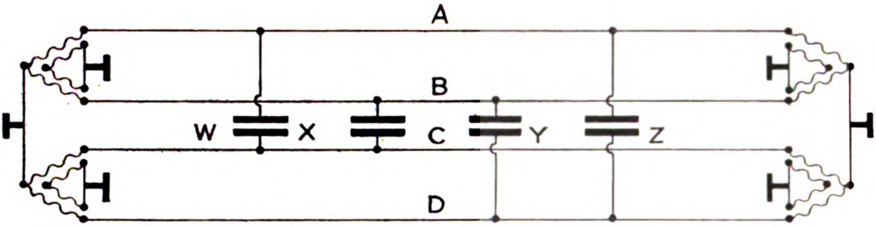


FIG: 1

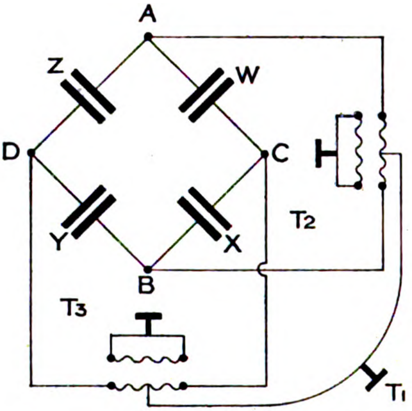


FIG: 1a.

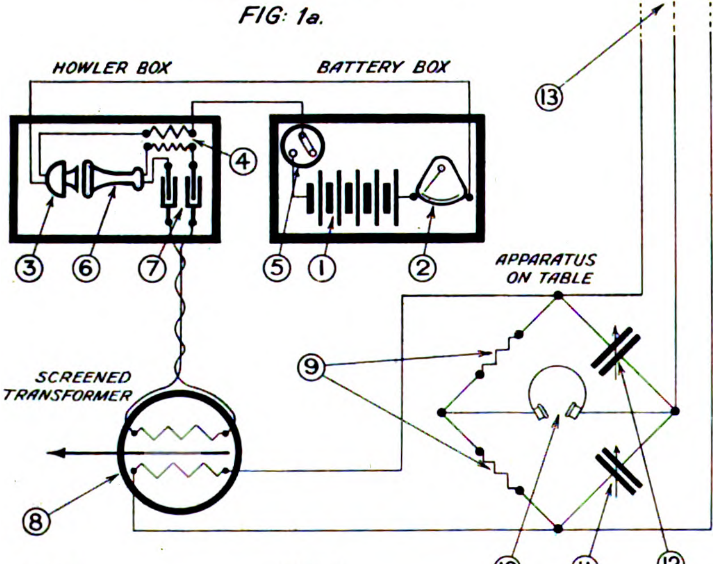


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FIG: 2

difference of potential between C and D. Then because the same quantity flows into W and X—

$$VwW = VxX \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Also for the same reason—

$$VzZ = VyY \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The potential of $C = Va - Vw$ and the potential of $D = Va - Vz$.

Therefore in order that there shall be no difference of potential between C and D, Vw must be equal to Vz and likewise Vx must be equal to Vy. If we make these equal then (1) and (2) become—

$$\frac{W}{Z} = \frac{X}{Y} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Similarly if we apply a difference of potential between CD, a balance is obtained between AB when—

$$\frac{W}{X} = \frac{Z}{Y} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The same result will be obtained by taking W, X, Y, Z as the capacity arms of a Wheatstone bridge and calculating their values from impedances to alternating currents. The last result is identical with (3), which therefore represents the only conditions for no interference between side and side circuits.

(2) *Conditions for no interference between the superimposed and side circuits.*—Referring again to **1a**, the wires AB together form one side of the superimposed circuit while the wires CD form the other. Consider the influence of the wires A and B forming one side of the superimposed circuit upon the side circuit composed of the wires C and D. In this instance there is no difference of potential between A and B, but there is a difference between these wires and CD. In order that there shall be no difference of potential between C and D, the same quantity must flow from A and B into C as into D. Let the difference of potential between A and C, B and C, A and D, B and D, be $Vab - Vcd$, then $(W + X)(Vab - Vcd) = (Z + Y)(Vab - Vcd) = Q$, that is—

$$W + X = Z + Y \quad . \quad . \quad . \quad (5)$$

Next consider the splitting of the current from T_1 into the two wires AB through the differential transformer. In order that T_2 may not be affected by T_1 the currents must divide equally between A and B, and this is only obtained when the two capacities—

$$W + Z = X + Y \quad . \quad . \quad . \quad (6)$$

Similarly it can be shown that for balance between the wires CD forming one side of the superimposed circuit and the side circuit AB the condition is—

$$W + Z = X + Y,$$

and when we take the splitting of the current from T_1 into the wires CD we must have for T_3 not to be affected—

$$W + X = Z + Y.$$

Equations (5) and (6) are therefore the conditions for no interference between the superimposed and side circuits.

(3) *Conditions for no interference between side and side circuits and between superimposed and side circuits simultaneously.*—These conditions are deduced from the preceding equations as follows:

From (5) $W - Z = Y - X$

„ (6) $W + Z = X + Y$

By addition $2W = 2Y$

$$W = Y \qquad (7)$$

By substitution in (6) $X = Z \qquad (8)$

Dividing (7) by (8) we get—

$$\frac{W}{X} = \frac{Y}{Z}$$

but from (4)

$$\frac{W}{X} = \frac{Z}{Y}$$

Therefore

$$\frac{Y}{Z} = \frac{Z}{Y}, \text{ and therefore } Y = Z \qquad (9)$$

Hence from (7), (8) and (9) we get:

$$W = Z = Y = Z \qquad (10)$$

as the condition for perfect balance between side and side and between side and plus circuits.

When testing the cable the following measurements are made on each core:

(i) $p = W - X$

(ii) $q = Z - Y$

(iii) $r = W - Z$

(iv) $s = X - Y$

where W, X, Y, Z are wire-to-wire capacities in the presence of other conductors and the sheath.

Now if we select from the test results wires which when jointed together make $p - q = o$ and $r - s = o$ (these are termed the side characteristics) and also $p + q = o$ and $r + s = o$ (these are termed the plus characteristics),

Then $p = o$, $q = o$, $r = o$, and $s = o$, *i.e.*

$$W - X = O$$
$$Z - Y = O$$
$$W - Z = O$$
$$X - Y = O$$

or $W = X = Y = Z$, which satisfies the condition for perfect balance.

In practice it is found better and easier to select wires for jointing so as to reduce the "side" and "plus" characteristics to zero than to select for the reduction of the values p, q, r, and s to zero. This is because (1) $p - q$ and $r - s$ are identities, hence there are only three values to consider instead of four, and moreover $p - q$ and $r - s$ are often so small that there are usually only two values to consider. (2) The changes which the side and plus characteristics undergo when wires are crossed are simpler than those which take place when we are dealing with p, q, r, and s. For example, suppose we cross the wires AB and the wires CD also. Then the new values of p, q, r, and s are $-q$, $-p$, $-s$, $-r$, *i. e.* both the signs and the order of sequence change, whereas $(p - q)$ $(p + q)$ and $(r + s)$ become $+ (p - q) - (p + q)$ and $- (r + s)$, *i. e.* a change only occurs in the signs. (3) $(b - q)$ and $(r - s)$ indicate the magnitude of the side to side out of balance, whilst $(p + q)$ and $(r + s)$ are a measure of the side to plus out of balance. Hence when we are dealing with these values instead of with p, q, r, and s, we can see more clearly to what extent we are reducing the "side" out of balance and the "plus" out of balance respectively. The method of selecting wires is dealt with in (III), but a description of the apparatus used for testing will be given first.

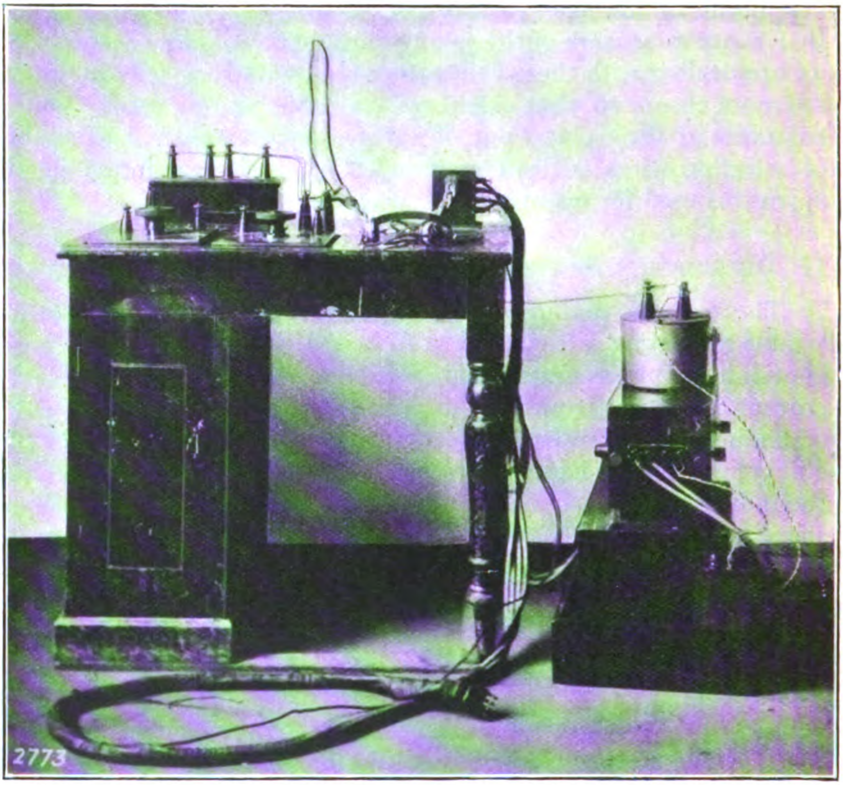
II. Description of Apparatus used and Method of Testing.

The tests are performed with a portable equipment contained in a table measuring 2 ft. 9 in. × 2 ft. × 2 ft. 6 in. high and two boxes containing the generator and batteries respectively. Alternating current of speech frequencies is provided by a generator consisting of an inset transmitter (*3*) (**2**) connected through a No. 2 induction coil (1^{ω} primary and 150^{ω} secondary) (*4*). In the primary circuit of the induction coil are the battery (*1*), consisting of six dry cells of size *Z*, milliammeter (*2*), transmitter (*3*), induction coil primary (*4*), switch (*5*).

In the secondary circuit of the induction coil are the telephone receiver (*6*) tuned to a high note by being nearly filled with wax and placed opposite to the transmitter at a suitable distance away, a tuning condenser of ·04 mfd. on one wire *or* preferably two condensers of ·08 mfd., one in each wire between the generator box and the specially screened transformer (*8*), the secondary of which feeds the capacity bridge.

The action of the generator is as follows: Closing the battery switch (*5*) causes current to flow in the transmitter circuit through battery (*1*), milliammeter (*2*), transmitter (*3*), induction coil primary (*4*); the current flowing in the primary induces current in the secondary circuit *viâ* condensers (*7*), special transformer (*8*), and receiver (*6*). This causes the diaphragm to move and transmit sound to the transmitter, which reacts again on the telephone receiver thus setting up a continuous complex sound or howl; hence the name "howler" by which this apparatus is usually known.

The measuring instrument is a Wheatstone bridge suitable for alternating current containing non-reactive ratio arms of 1000 + 1000 ohms (*9*) and two continuously graduated air condensers. Instead of the non-reactive resistances the secondary of a transformer No. 2 which has been specially balanced for the work may be used, the primary being insulated. This arrangement is more sensitive than the 1000-ohm arms for testing short lengths of cable owing to the mutual induction between the windings making it non-inductive to the telephone current and highly inductive to the power current.



Testing Table with Apparatus.

On the other hand, great care must be taken in the selection to see that only an accurately balanced transformer is used and that its accuracy is frequently checked. If accurate the ratio arms will bear reversal without altering the reading of the condensers. The wires of a pair in the cable are joined to the ends of the bridge as in diagram **2** and two variable air condensers (*11* and *12*) are bridged across in series. One of the wires of the other pair in the same core is brought to the centre point of the two condensers, and the telephone (*10*) is bridged from this point to the middle of the ratio arms.

A wireless headgear telephone receiver providing maximum sensitivity is used for this work. The specially balanced transformer

(*8*) has an electrostatic screen between the primary and secondary windings. The capacities of both these windings are balanced to the screen in such a manner that when the screen is connected to earth the transformer feeding the bridge can be reversed with respect to the bridge without affecting the zero of the bridge or the balance obtained. This is essential to accuracy of measurement.

Let *A B C D* be the wires respectively of a four-wire core, *A* and *B* forming one pair and *C* and *D* forming the other pair.

A four-way clip, 3 (*17*) is placed on these wires, and a connecting plug (*18*) terminating four heavy rubber insulated and earth screened leads (*14*) is connected to the clip (*17*), the other end of the leads being connected to a special plug and switch (*16*) and (*15*).

The function of this plug and switch is to perform the following operations:

Connect *A* and *B* to the bridge, and *C* to the telephone for test *p*.

Connect *A* and *B* to the bridge, and *D* to the telephone for test *q*.

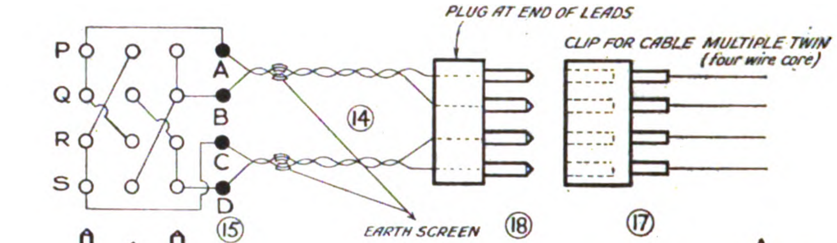
Connect *C* and *D* to the bridge, and *A* to the telephone for test *r*.

Connect *C* and *D* to the bridge, and *B* to the telephone for test *s*.

Plugging into the four positions marked *P Q R S* with the plug (*16*) makes the necessary connections. A few notes upon the practical handling of the testing set are necessary.

The middle pin of the plug is shorter than the other two, in order that the telephone connection may be made last. If this is not done the current through the telephone on plugging in will be excessive and somewhat annoying to the ear. Especially is this the case when testing lengths of cable of half a mile and upwards and using mutual induction in the arms of the bridge (when a repeating coil is used instead of non-inductive arms). It is essential that all the springs and plugs in circuit should make good and reliable contact. If they do not, endless trouble will be caused and it will be impossible to balance the bridge in the majority of cases. Long lengths of cable are very exacting in this particular.

The variable condensers should be connected so that the terminal which is joined up to the moving arm is also connected to the telephone. In making the test the variable condenser connected to the *A* or *C* wire is moved, the other remaining fixed. Before starting to test, set the (*A*) condenser to its middle or other fixed point, usually 100, and set the *B* condenser to balance. Now reverse the two condensers with respect to the bridge arms; they should absolutely balance without alteration if the bridge arms are accurately adjusted. If they are not they ought not to be used.



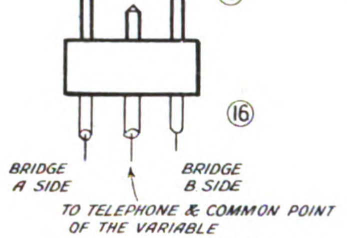


FIG: 3.

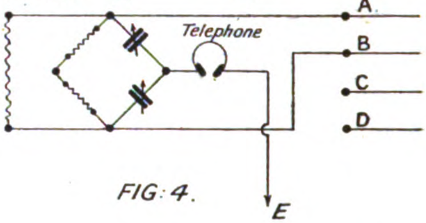


FIG: 4.

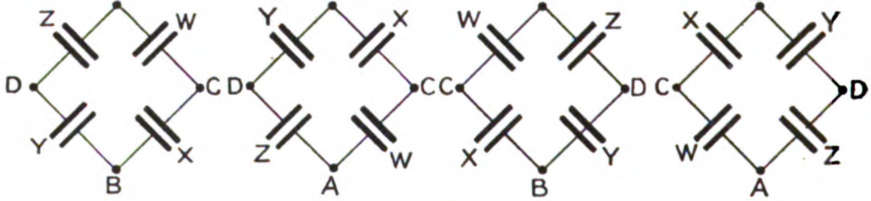


FIG: 5

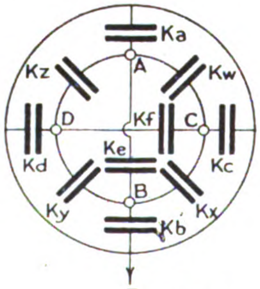


FIG: 6

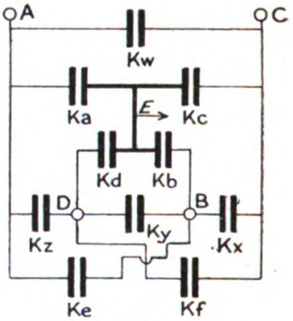


FIG: 7

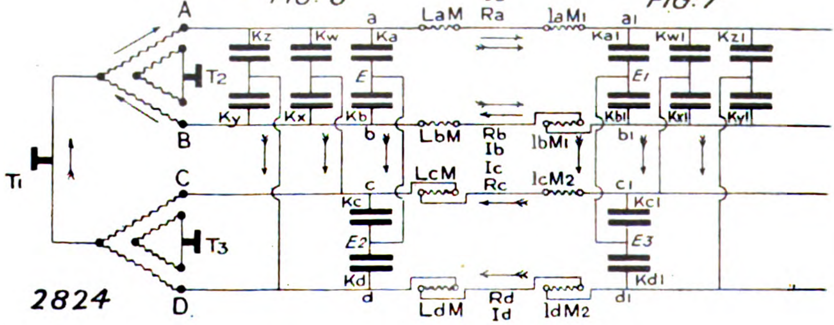


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FIG: 8.

During this preliminary check the plug switch is not in use and the leads are therefore disconnected. Place the 3-way plug in the (*p*) position, balance on the air condenser, reverse the plug and balance again. Both the readings should be at the same point as the zero. If they are not it means that the capacity of the *A* lead to the *C* lead is greater or less than that of the *B* lead to the *C* lead, according as the reading of the condenser is smaller or greater than the zero or middle point.

The middle point or zero is usually taken at 100, and below 100 is taken as positive. Thus 90 is called + 10, while 110 is negative and is called —10. The reason is that the capacities of the variable condensers are put in to *add* to the capacities of the cable in order to make the total capacities equal; thus, if a smaller capacity is added on one side, it means that the wire of the cable on that side has a greater capacity to the wire on the telephone than its companion wire in the same pair.

In order to test the leads up to the connecting plug (*18*) (3) and balance them the telephone may be placed between the middle point of the condensers and earth (4). A small capacity to earth is connected with *A* or *B* and the value of the capacity varied by small steps until a balance is obtained. Usually the amount required is very small, and can be readily provided by taking a few inches of the special copper braided thick rubber-insulated wire used for the leads, and sealing up the disconnected end with Chatterton compound to ensure good insulation between the conductor and the braid. The balance may be checked by interchanging the two air-condensers, which, if the balance is correct, will not require readjustment. The leads *C* and *D* may be balanced in like manner. If earth is now removed from the telephone and *C* and *D* connected to the telephone instead, the leads *A* and *B* will now be found to be balanced. This method only holds good if the leads are properly screened by an earth-connected metallic braid all along their length, but is a very accurate one. The bridge arrangement shown in **2** may also be used for balancing the leads to earth, the middle point of condensers in that case being earthed. The zero of the condensers may always be checked by reversing the 3-plug switch. After reversal the reading should be as much on one side of zero as it was before on the other (This also checks whether the value, say, of 30 division above zero is equal to 30 division below zero.)

To make the test of the cable both the ends are opened and the wires fanned out. Two or more clips are used to expedite the work, the ones not in use being put on the cable in readiness for the next core to be tested, so that the testing leads may be transferred without loss of time.

Care is taken to see that the wires are placed on the clip properly and the clip on the leads properly, according to the following scheme:

Leads.	Wires.	Pairs.	Core.	Pairs.	Core.
A connected to *a*	wire red string	red	red or blue	blue	white or green
B connected to *b*	wire white string				
C connected to *a*	wire red string	white		green	
D connected to *b*	wire white string				

Readings are then taken with the 3-way plug in the four positions of the switch. These represent the differences p, q, r and s mentioned previously, and are read directly to the nearest division of the air-condensers above (minus) or below (plus) zero. The maximum value of the air condensers is approximately 0·0012 mf. The scale is divided into 180 divisions. Each division represents approximately 0·1 per cent. error in capacity in the case of 175 yds. of a 108-wire 100-lb. multiple twin cable. It is possible with the 1000-ohm ratio arms to read to 0·5 division, and with higher arms to about 0·2 division when testing the single lengths with the ordinary equipment. On longer lengths the sensitivity is much greater. For instance, on two and a half miles of cable measuring 0·15 mf. wire-to-wire capacity one division on the air condenser represents about 6 parts in 150,000 of the cable, and the sensitivity of the arrangement with an efficient "howler" and mutual inductive ratio arms is sufficient to read to one-sixth division if a perfect zero of sound is obtainable when balanced. To obtain this great sensitivity it is necessary to balance the conductor resistance and leakance discrepancies of the wires under test if such discrepancies exist by introducing a small slide wire of 1 ohm or less into one or other wire of the pair. But a better though more expensive arrangement is the use of a 100-ohm slide wire between the two air condensers with the sliding contact connected to the telephone and the middle wire. The latter arrangement eliminates possible trouble with the contact resistance of the slider. This refinement is not required in practice so long as imperfect contacts do not exist in the switch and plugs between the bridge and the cable, and the resistances of the wires in the pair under test are reasonably matched and the cable dry. Failure to obtain absolute zero of sound on attempting to balance usually indicates one or more of these defects if the accessory apparatus has been properly designed and constructed in the first instance. For purposes of selection it is not necessary to record fractions of a division; the nearest division is ample for the purpose.

The actual equipment used with each testing set consists of a table fitted up with the apparatus described in the foregoing, the connections being made by means of highly insulated leads. All terminals are mounted on ebonite pillars.

A light furniture van may be conveniently used to carry the apparatus from section to section. The tests can then be carried out from the van in wet weather. The vans should be fitted with dumpy stoves in order to keep the atmosphere as dry as possible in bad weather. In fine weather the tests may be made in jointer's tents.

But where expedition is a matter of great importance and the lengths can be got ready for testing quickly enough the testing set can be more permanently installed in a light motor van. The most economical procedure is to arrange for the testing van to follow closely behind the gang or gangs drawing in the cable lengths. This saves the expense and time of opening up the ground again for testing the ends, but limits the rate of testing. It has been found that where holes had already been filled in each testing van accompanied by seven men to open up the ground, prepare the cable ends, connect the testing clips, and to close and re-cap the cable after test could deal with sixteen cable lengths per day.

This rate of progress, however, is difficult to maintain, and twelve cable lengths per day may be considered a good average in favourable weather. A second testing set is employed to test the longer sections of four or five lengths after the single lengths have been joined up by the jointers.

III. Method of Selecting Wires to be Joined together.

As already explained, the object of the system is to join adjacent sections of cable together in such a way that the capacities between the wires of each core should as nearly as possible fulfil the conditions for balance both between the side circuits and between the side and superimposed circuits. The principles upon which selection of the wires is based will first be explained and the actual procedure will be described afterwards.

There are two steps in the selection of suitable wires to be joined together: first, the selection of the cores; secondly, the method of joining up the selected cores.

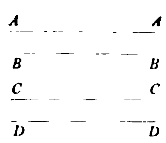
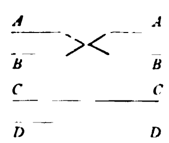
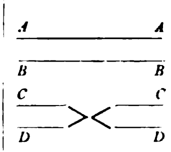
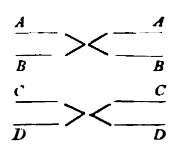
It will simplify the explanation if the second of these steps is considered first.

The cable dealt with is a multiple twin type composed of four-wire cores. It is essential that complete cores should be joined together; that is, the two pairs forming one core in a length of cable cannot be joined through to two pairs in different cores in the adjacent length of cable. Hence, supposing that the two cores to be joined together have been chosen there are eight ways of connecting the wires of the cores. If one length is imagined straight, *i.e.* as represented by the order of the wires in 1A, the adjacent length may be joined to it in any of the orders shown in **5**, *i.e.* (1) straight, (2) wires *AB* reversed, (3) wires *CD* reversed, (4) both *AB* and *CD* reversed. Combinations (5), (6), (7) and (8) are obtained by crossing the two pairs and connecting the wires of the pairs as in (1), (2), (3) and (4).

It is necessary to find the effect of these operations on the values of the measured quantities p, q, r and s. This can best be seen by reference to the diagrammatic representation of the core sections shown in **5**.

It will be seen that by reversing *AB*, p or $(w - x)$ becomes $-p$ or $(x - w)$; q becomes $-q$, while r and s are interchanged. Similarly upon reversing *CD*, p and q are interchanged and the signs of r and s become negative. Upon reversing both *AB* and *CD* the signs of p, q, r and s become negative; p and q are interchanged and r and s are interchanged. These effects may be tabulated as shown in Table I.

TABLE I.

	 Straight.	 *AB* crossed.	 *CD* crossed.	 *AB*, *CD* crossed.
P, Q, R, S become .	P, Q, R, S	$-P, -Q, S, R$	$Q, P, -R, -S$	$-P, -Q, -S, -R$
$(P - Q)$ becomes .	$(P - Q)$	$-(P - Q)$	$-(P - Q)$	$(P - Q)$
$(R - S)$ becomes .	$(R - S)$	$-(R - S)$	$-(R - S)$	$(R - S)$
$(P + Q)$ becomes .	$(P + Q)$	$-(P + Q)$	$(P + Q)$	$-(P + Q)$
$(R + S)$ becomes .	$(R + S)$	$(R + S)$	$-(R + S)$	$-(R + S)$

If the pairs are crossed P and Q are interchanged with R and S, the signs remaining as shown in the above table. These changes are also shown in another form in Table II.

It is clear that the cores, which have been assumed chosen, should be joined together in such a way as to reduce the "side" and "plus" circuit characteristics to as near zero as possible. That is, the values of $(p - q)$ $(p + q)$ and $(r + s)$ should be opposite in sign and of the same magnitude for the two cores. The magnitude is that which governs the choice of cores and will be dealt with later. The sign can be regulated by crossing the wires as shown in the above table. That combination should be chosen which reduces each of the characteristics. A numerical example will make this clear.

TABLE II.—*Values which must be Added Together for the Calculation of Residual Balance Differences when Crosses are made.*

Crosses made.	Equivalent arrangement of wires and capacities in core.	Values in top line are to be added to the values in the same vertical columns corresponding to the cross made.			
None	A $z \quad w$ $D \qquad C$ $y \quad x$ B	$w - x = p$	$z - y = q$	$w - z = r$	$x - y = s$
Pairs and *CD*	D $y \quad z$ $B \qquad A$ $x \quad w$ C	$z - w = -r$	$y - x = -s$	$z - y = q$	$w - x = p$
AB and *CD*	B $x \quad y$ $C \qquad D$ $w \quad z$ A	$y - z = -q$	$x - w = -p$	$y - x = -s$	$z - w = -r$
Pairs and *AB*	C $w \quad x$ $A \qquad B$ $z \quad y$ D	$x - y = s$	$w - z = r$	$z - w = -p$	$y - z = -q$
Pairs	C $x \quad w$ $B \qquad A$ $y \quad z$ D	$w - z = r$	$x - y = s$	$w - x = p$	$z - y = q$
CD	A $w \quad z$ $C \qquad D$ $x \quad y$ B	$z - y = q$	$w - z = p$	$z - w = -r$	$y - x = -s$
Pairs and *AB* and *CD*	D $z \quad y$ $A \qquad B$ $w \quad x$ C	$y - x = -s$	$z - w - -r$	$y - z = -q$	$x - w = -p$
AB	B $y \quad x$ $D \qquad C$ $w \quad w$ A	$x - w = -p$	$y - z = -q$	$x - y = s$	$w - z = r$

Example I.

Two cores have the following measured values:

Core A. $p = +2, q = +4, r = +24, s = +26.$
Core B. $p' = -7, q' = -6, r' = +30, s' = +31.$

The core characteristics are deduced as follows:

Core A. $(p - q) = (r - s) = -2;\ (p + q) = +6;\ (r + s) = +50.$
Core B. $(p' - q') = (r' - s') = -1;\ (p' + q') = -13;\ (r' + s') = +61.$

The following points should be noticed:

(1) The large values of the plus circuit characteristics occur in the case of the same quantity, namely $(r + s)$ in both cases. We do not require to interchange the values $(p + q)$ and $(r + s)$, therefore we do not cross the pairs.

(2) The characteristics $(p + q)$ and $(p' + q')$ are opposite in sign, whilst $(r + s)$ and $(r' + s')$ are of the same sign. It is therefore necessary to cross the wires of pair *CD vide* Table I, *AB* remaining straight. This alters the sign of $(p' - q')$ and $(r' - s')$ as well as the sign of $(r' + s')$, as the foregoing table shows. The resulting characteristics of the two lengths then become:

$$
\begin{aligned}
(p - q) + (p' - q') &= -2 + 1 = -1,\\
(p + q) + (p' + q') &= +6 - 13 = -7\\
(r + s) + (r' + s') &= +50 - 61 = -11.
\end{aligned}
$$

Similarly the new values of P, Q, R, and S resulting from the combination of the two cores when the wires *CD* are crossed become (*vide* Table II):

$$
\begin{aligned}
P &= p + q' = +2 - 6 = -4\\
Q &= q + p' = +4 - 7 = -3\\
R &= r + (-r') = +24 - 30 = -6\\
S &= s + (-s') = +26 - 31 = -5
\end{aligned}
$$

Example 2.

Core A. $p = -5, q = -7, r = +15, s = +13.$

Core B. $p' = +11, q' = +11, r' = -8, s' = -8.$

Here the characteristics are:

$$
\begin{aligned}
&(p - q) = (r - s) = +2;\ (p + q) = -12;\ (r + s) = +28\\
&(p' - q') = (r' - s') = 0;\ (p' + q') = +22;\ (r' + s') = -16.
\end{aligned}
$$

Inspection of the plus circuit characteristics shows that pairs must be crossed in order to interchange the quantities $(p' + q')$ and $(r' + s')$, and also that the wires *AB* must be crossed to change the sign of $(p' + q')$, and the wires *CD* must be crossed to change the sign of $(r' + s')$, *vide* Table I. The resulting characteristics of the two lengths then become—

$$
\begin{aligned}
(P - Q) = (R - S) = (p - q) + (p' - q') = (r - s) + (r' - s') &= +2 + 0 = +2.\\
(P + Q) = (p + q) + (-(r' + s')) &= -12 + 16 = +4\\
(R + S) = (r + s) + (-(p' + q')) &= +28 - 22 = +6
\end{aligned}
$$

Similarly, the new values of P, Q, R, and S (*vide* Table II), become—

$$
\begin{aligned}
P &= p + (-s') = -5 + (-(-8)) = +3.\\
Q &= q + (-r') = -7 + (-(-8)) = +1.\\
R &= r + (-q') = +15 + (-11) = +4.\\
S &= s + (-p') = +13 + (-11) = +2.
\end{aligned}
$$

The choice of suitable cores to be joined together is governed by two considerations. The first has been already mentioned, *i. e.* the numerical magnitude of the side and plus circuit characteristics should be of the same order, so that the resultant differences may be small.

The second consideration is that which ensures the reduction of both the side and phantom circuit characteristics. Referring to Table I, showing the change of signs of the characteristics resulting from crossing the wires, it will be seen that any one operation of crossing the wires of a pair changes the signs of three of the characteristics. It will be found upon trial that the signs of the characteristics of a core all of which are measured as positive, can be changed as shown in Table III in the group marked Type A, whilst those which are all measured as negative can be changed as shown in the group marked Type B.

TABLE III.

	$(P-Q)=(R-S)$	$(P+Q)$	$(R+S)$	
Straight	+	+	+	Type A
Cross *AB*	−	−	+	
Cross *CD*	−	+	−	
Cross *AB*, *CD*	+	−	−	
Straight	−	−	−	Type B.
Cross *AB*	+	+	−	
Cross *CD*	+	−	+	
Cross *AB*, *CD*	−	+	+	

It will be noticed that in the four possible arrangements of wires in group A the signs of the three characteristics of one arrangement in no case are all opposite to the signs of the three characteristics in any of the other arrangements. That is, if two cores, both possessing characteristics of the signs shown in the first group, are joined together, it is impossible to reduce both the side and plus characteristics. The same is true of the second group. If, however, a core with characteristics belonging in sign to the first group is joined to one of the second group, both the side and plus characteristics can be reduced. For convenience of reference cores belonging to these two groups are referred to as type A and type B cores respectively. All cores belong either to type A or type B, and wherever possible cores of opposite types should be chosen for joining together. The following numerical example will make the method of choosing cores clear:

Two sections of 6-core cable are to be joined together. The measurements are as shown under p, q, r, s.

Cable length.	Core number.	p	q	r	s	$p - q$	$r - s$	$p + q$	$r + s$	Type.
A	1	− 14	− 14	+ 3	+ 3	0	0	− 28	+ 6	*A* or *B*
	2	− 16	− 18	+ 7	+ 6	+ 2	+ 1	− 34	+ 13	*B*
	3	− 10	− 8	+ 9	+ 11	− 2	− 2	− 18	+ 20	*A*
	4	+ 6	+ 7	− 6	− 6	− 1	0	+ 13	− 12	*A*
	5	+ 1	+ 3	− 3	− 1	− 2	− 2	+ 4	− 4	*A*
	6	+ 10	+ 10	− 8	− 8	0	0	+ 20	− 16	*A* or *B*
B	1	− 15	− 13	+ 7	+ 9	− 2	− 2	− 28	+ 16	*A*
	2	+ 9	+ 10	+ 8	+ 9	− 1	− 1	+ 19	+ 17	*B*
	3	− 14	− 13	+ 5	+ 6	− 1	− 1	− 27	+ 11	*A*
	4	− 4	− 2	− 5	− 3	− 2	− 2	− 6	− 8	*B*
	5	− 10	− 9	− 4	− 3	− 1	− 1	− 19	− 7	*B*
	6	+ 8	+ 7	+ 7	+ 6	+ 1	+ 1	+ 15	+ 13	*A*

Taking core 1A, it is required to find a suitable core in cable Section B to which to join it. Since the side characteristics are zero, the type is immaterial, but the side characteristics of the chosen core should be small. Core 3B is the most suitable as regards magnitude of the characteristics.

Core 2A requires a type A core in cable Section B. Core 1B has characteristics of the same order of magnitude and is of the right type.

Similarly the other selections are made as shown in the table below, the necessary crosses being deduced from inspection of the core characteristics as previously explained.

Core number.		Cross.
Section A.	Section B.	
1	3	*A*, *B*, and *C*, *D*.
2	1	*A*, *B*, and *C*, *D*.
3	2	*A*, *B*, and pairs.
4	5	*C*, *D*.
5	4	*C*, *D*.
6	6	*A*, *B*.

Method of Procedure in Selecting.—In order to deduce the best combinations of cores from the test results, the following operations are carried out:

(1) The values of the core characteristics $(p - q)$, $(r - s)$, $(p + q)$ and $(r + s)$ are deduced from the test values of p, q, r, and s, and filled in on the test sheets.

(2) The core characteristics are tabulated for each cable section in descending order of magnitude of the plus circuit characteristics, the maximum value being taken in each core.

The four characteristics and the types are filled in on this schedule.

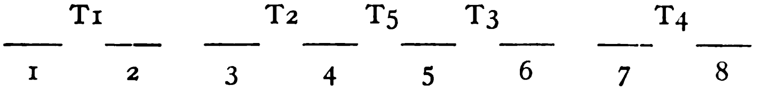
(3) The selections are made and tabulated from this schedule, starting with cores having high values. The cores of one cable section are written in order of rotation as they are laid up in the cable, the effect of all crosses being calculated on the other cable section.

(4) The values of the residual differences p, q, r and s are calculated. This step is a check upon the previous calculations and also upon the crosses made in operation (3).

(5) Jointing schedules are made out for use by the jointers.

The above procedure applies to two lengths of cable only. In practice certain modifications are made which give much better results. In the case of a cable which it is proposed to load, the cable is divided up into sections corresponding to those between loading coils.

Each loading coil section is balanced in itself as regards capacity as nearly as possible. There are usually twenty-five cable sections between each loading coil. These sections are grouped into three, two containing eight and one nine sections. The eight section length is tested in the order indicated by the letters T1, T2, etc., in the diagram :



The joints between sections 2 and 3 and between 6 and 7 are deduced from the results of combining 1 + 2 and 3 + 4, etc. In practice better results are obtained by selecting lengths 1, 2, 3 and 4 together, so that the resultant characteristics of 1 + 2 suit those of 3 + 4.

When there are five sections to be joined, the joint between Nos. 1 and 2 or that between Nos. 4 and 5 is selected first in the usual way. The four lengths made up of 1 + 2, 3, 4 and 5 are then selected, the resultant of two of the lengths being made to cancel out with the other three sections.

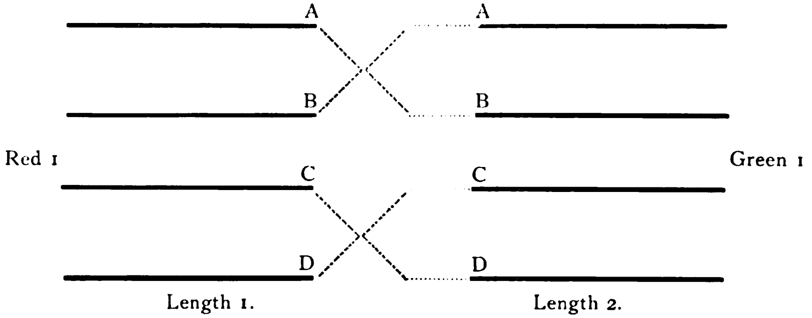
When joints Nos. 1–2, 2–3, 3–4, 5–6, 6–7 and 7–8 have been made, a test is made at the junction of 4 and 5 and the joint is selected from the results of this test.

Finally, tests are made at the junctions of the three component sections of each loading coil section and the two joints selected from these results.

Referring to operation (3) it is important to remember that the calculated values of the residual differences refer to the cable section which has been kept straight.

For example, suppose we are joining together two lengths, 1 and 2, keeping 2 straight and calculating the effect of all crosses on 1. Then the calculated residual differences will refer to the end of length 2—that is to say, the calculated residual differences are those which would be obtained if we tested the two lengths from the end of length 2. Obviously, since the wires of the cable when tested are always connected up to the testing leads in a particular order, these residual differences are not the same as those which would be obtained if we tested from the end of length 1.

An example will perhaps make this clear. Suppose we have joined core Red 1 to core Green 1, as shown in the following diagram:



And suppose when we test from the end of length 2, the residual differences are $+P$, $+Q$, $+R$, $+S$.

If we had tested from the end of length 1, the residual differences would have been $-Q$, $-P$, $-S$, $-R$; and, moreover, these differences would refer to core Red 1, whereas when we tested from the end of length 2, the differences referred to core Green 1.

In order to decide which length to keep straight when joining two lengths together it must be borne in mind where the "deduced" joint is to be made. For example, if we are joining together lengths 1, 2, 3 and 4, we first test the differences p, q, r and s on each of the four lengths. We then join 1 and 2 together, and also 3 and 4 together, and calculate the residual differences for 1 and 2, and 3 and 4. The next thing is to select joint 2–3 (termed the "deduced" joint) from these calculated residual differences. Therefore the residual differences for lengths 1 and 2 should refer to length 2, and the residual differences for lengths 3 and 4 should refer to length 3.

Hence when joining 1 and 2 we should keep length 2 straight, and when joining 3 and 4 together we should keep length 3 straight.

Degree of accuracy obtainable.—The residual out-of-balance of capacity obtained on the various lengths of a loading-coil section of 2·5 miles approximate length depends largely on the number of cores in the cable. In the case of a cable in which the selections are confined to twelve cores in the same layer the out-of-balance occurring at each stage is shown in Appendices I and II. On analysis the results are approximately as follows:

Single lengths, 4 per cent. maximum.
Four „ 0·275 per cent. maximum, ·04 average.
Eight „ 0·070 „ „ ·0156 „
Twenty-six „ 0·022 „ „ ·0045 „

The above quantities represent the percentage out-of-balance in the capacities W, X, Y, Z, and are measured values. The deduced results are usually slightly smaller. This means that many cores are obtained in practice between loading-coil points which are practically perfect, the out-of-balance not exceeding 1 in 100,000 parts.

It will probably have been noticed that the capacities balanced by the method described are only resultant wire-to-wire capacities in the presence of other conductors and the sheath, and do not include the wire-to-earth capacities as would be measured by connecting the corner of the bridge to earth, which in **2** is connected to D. On referring to **1** it will be seen that so long as the source of current is not connected to earth it cannot supply current to charge a capacity to earth except in series with other capacities. **6** shows the complex arrangement of capacities which correspond to the resultants W, X, Y, Z, and **7** the resultant between A and C. The true wire-to-wire capacities are represented by Kw, Kx, Ky, Kz, Ke, Kf, and the true wire-to-earth capacities by Ka, Kb, Kc, Kd. The theory so far has been developed upon the assumption that the capacities which should be balanced are the resultant capacities as measured with no earth on the testing apparatus, and the results observed by speech confirm this assumption on lengths tested before loading coils have been inserted. But the question naturally arises: How do the earth capacities which may be out of balance on either side of loading coils affect cross-talk? The conclusion arrived at is that so long as the source of current for speaking has no out-of-balance capacity or leakage to earth before it reaches the cable, earth balances are not required, or when well insulated transformers having balanced electro-static screens between primary and secondary windings are interposed between such defective circuits and the loaded cable, earth balances are not required. But the arguments for this conclusion will now be discussed.

8 represents the connections at one end of a circuit $T1$, superimposed upon two loops $T2$ and $T3$, including plus and side loading coils inserted between the first two sections of the line.

The self-inductances of the four windings of the plus coil are shown as La, Lb, Lc, Ld; of the two windings of the side coils in $T2$ as la and lb, and of the side coil in $T3$ as lc and ld. The mutual inductance of the windings in the plus coil is shown as M, and of the windings of the side coils as $M1$ and $M2$ respectively. Ra represents the sum of the resistances of the windings between *a* and *a*1; similarly *Rb*, *Rc*, *Rd*, the resistances between the other corresponding points in *B*, *C* and *D*. The wire-to-earth capacities in the first loading coil section are represented by *Ka*, *Kb*, *Kc* and *Kd*, whilst corresponding wire-to-earth capacities in the second section are represented by *Ka* 1, *Kb* 1, *Kc* 1 and *Kd* 1.

It was shown at an earlier stage that one of the conditions for no overhearing on *T*2 when speaking on *T*1 was an exact division of the current from *T*1 through the differential transformer, and that this was obtained when the resultant capacities between *A* and *CD* were made equal to the resultant capacities between *B* and *CD*, assuming that the conductor resistances and leakances were already balanced. The resultant capacities as measured are made up of a complex combination of wire-to-wire and wire-to-earth capacities as indicated in **6** and **7**. The resultant capacity between *A* and *C* is made up of ten capacities as in **7**, and a similar diagram would represent the capacities between *B* and *C*. To obtain the resultant capacity in terms of all the capacities shown is extremely laborious, and the result contains too many terms for simple application. But, by making certain assumptions which are approximately true, the capacities shown in **6** can be divided into two symmetrical groups representing the two resultant capacities *W* and *X* as measured on the testing apparatus. When these two groups are equated it can be seen how the balancing of the resultant capacities *W*, *X*, *Y*, *Z*, affect the individual capacities of which they are made up.

If we assume that the wire-to-wire capacities, *Kw*, *Kx*, *Ky*, *Kz*, *Kf* are equal to each other and *Ka*, *Kb*, *Kc*, *Kd* are also equal to each other, then, from the symmetry of **6** we may say:

$$Kw + \frac{1}{\frac{1}{Ka} + \frac{1}{Kc}} + \frac{1}{\frac{1}{\frac{1}{\frac{1}{Kd} + \frac{1}{Kc}} + Kf} + \frac{1}{Kz}} =$$

$$= Kx + \frac{1}{\frac{1}{Kb} + \frac{1}{Kc}} + \frac{1}{\frac{1}{\frac{1}{\frac{1}{Kd} + \frac{1}{Kc}} + Kf} + \frac{1}{Ky}}$$

If we further assume that the wire-to-wire capacities are 70 per cent. of the wire-to-earth capacities and substitute relative numerical values we obtain for the first term ·7, for the second term ·5, and for the third term ·44. The capacities which are not common to both sides are *Kw*, *Ka*, *Kz*, *Kx*, *Kb* and *Ky*. If we give small equal increments to *Kw*, *Ka* and *Kz*, one at a time, and observe the effect upon the sum of the series we see that the balance is very sensitive to a change in *Kw*, and much less sensitive to a change in *Ka* or *Kz*. In other words, the second term is less variable than either the first or the third term. Consequently, in balancing the resultant capacities, we are principally balancing the wire-to-wire capacities and to a much less extent the wire-to-earth capacities. This has been proved by actual measurements of the wire-to-earth capacities after the resultant capacities have been balanced. Referring to **8**: For silence to be obtained on the side circuit AB when speaking on the plus, the current Ia in one of the windings of the side coil must be equal to the current Ib in the other winding of the same side coil, for, if not, an E.M.F. will be impressed round the loop, of which the windings form portions of the sides according to the equation :

$$E = M1 \frac{d}{dt} (Ia - Ib).$$

These currents will be equal to each other if the following conditions are fulfilled: (1) The impedances between points in C and corresponding points in A and B (such as c, a, b, and $c1$, $a1$, $b1$) are equal to each other and also those between D and corresponding points in A and B before the coils are inserted; (2) the E.M.F. absorbed between the points a and $a1$ is equal to the E.M.F. absorbed between b and $b1$, according to the following equations:

$$Ea = Ra\, Ia + La \frac{d}{dt} (Ia) + M \frac{d}{dt} (Ib) + la \frac{d}{dt} (Ia) + M1 \frac{d}{dt} (Ib),$$

$$Eb = Rb\, Ib + Lb \frac{d}{dt} (Ib) + M \frac{d}{dt} (Ia) + lb \frac{d}{dt} (Ib) + M1 \frac{d}{dt} (Ia).$$

The first condition may be obtained by balancing the impedances of the various sections of A and B to C and D, and the second condition by balancing the windings in each loading coil during construction for inductance and resistance. In **8** the unfeathered arrows represent at a given instant the flow of current in the side circuit when speaking on $T2$, and the feathered arrows represent the current when speaking on $T1$. Take first the case of speaking on $T1$; a difference of potential will exist between the pair AB and the pair CD, and if the wire-to-earth capacities Ka, Kb, Kc, Kd are approximately equal, the points E and $E1$ will be intermediate in potential between the pairs AB and CD. Let AB be above E at a given instant, then the feathered arrows show the direction of current from the higher to the lower potential. It will be observed that no interchange of current can take place between a and $a1$ or b and $b1$ *viâ* the points E and $E1$, for that would mean a flow of current back into the line from a lower to a higher potential. Similarly, no interchange can take place between C and $C1$ or d and $d1$ *viâ* $E2$ and $E3$, for that would mean a flow from the pair CD to earth from a lower to a higher potential. If there be no interchange of current *viâ* E and $E1$, or *viâ* $E2$ and $E3$, then the wire-to-earth out-of-balance capacity taken by itself cannot interfere with a proper division of current through the

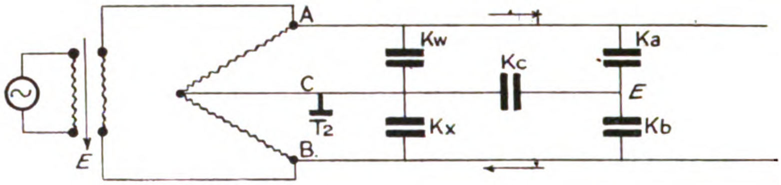


FIG: 9.

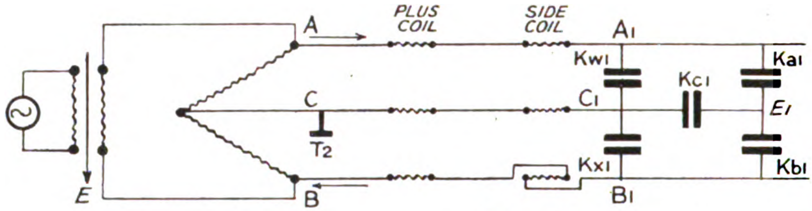


FIG: 10

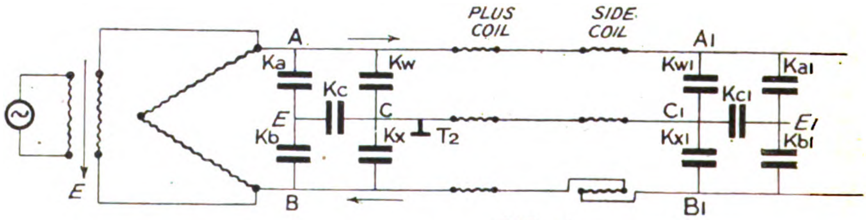


FIG: 11

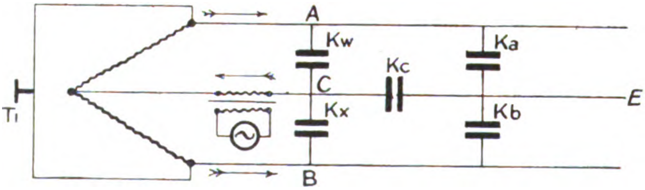


FIG: 12

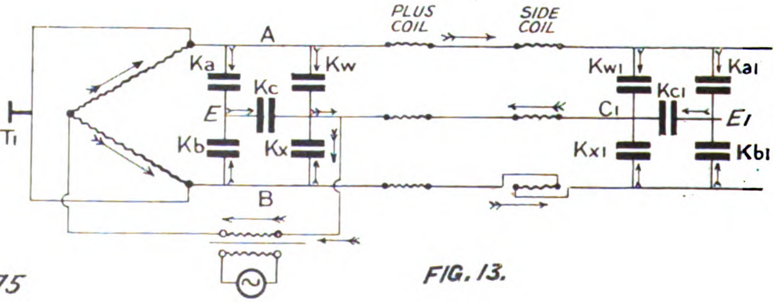


FIG. 13.

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loading coils. This may be seen more clearly by following the arguments based on **9**, **10**, **11**, **12** and **13**, which have been prepared to settle this point. **9** illustrates the conditions which obtain when the wires $A\ B$ are on the testing-bridge and the telephone is connected to C. The power is applied between A and B. Under this condition balance is obtained when—

$$Kw + \frac{1}{\frac{1}{Kc} + \frac{1}{Ka}} = Kx + \frac{1}{\frac{1}{Kc} + \frac{1}{Kb}}$$

These may be regarded approximately as the resultant capacities W and X of the first loading coil section. **10** shows the conditions under which balance would be obtained if a test were made of the second loading coil section with the coils inserted between the section and the testing apparatus. **11** combines **9** and **10**, but shows the telephone connecting the two neutral points of the capacity systems in each section, *i. e.* in circuit on the C wire. It is evident from this figure, if absolute potentials are neglected, that when the resultant capacity system of the pair $A\ B$ is balanced to the wire C on both sides of the loading coils no current will flow along the wire C due to earth capacities being out of balance on either side of the loading coils. But we can determine also the relative potentials of the points C and $C1$ with respect to each other by comparison with the potential of the ratio arms. The potentials of the ends of the ratio arms will be governed by the capacity to earth of the wires A and B. The point C will be midway between these two potentials when the first loading coil section is balanced. If the previously balanced second loading-coil section has a different wire to earth balance, and is now added to the first loading coil section, the absolute potentials of the ratio arms will be altered, but the point C will still remain midway between these new absolute potentials. As the point $C1$ is also midway between the points A and B, the points C and $C1$ must be at the same absolute potential. This matter has been dwelt upon at some length, because it is a matter of great importance to determine whether selections must be made for earth balancing as well as for balancing the resultant capacities. Referring to **11** again and the equation—

$$Kw + \frac{1}{\frac{1}{Kc} + \frac{1}{Ka}} = Kx + \frac{1}{\frac{1}{Kc} + \frac{1}{Kb}}$$

it is evident that unless $Kw = Kx$ the capacity Kc will receive a charge. In that event the points C and $C1$ cannot be at the same potential as E or $E1$. In practice they are, of course, never far away from earth potential. **12** illustrates the interchange in position between the source of testing power and listening telephone and represents speaking on the plus. **13** is an extension of the last diagram to include two sections with loading coils between them. The arrows indicate the path of the currents and the wire *D* is omitted for the sake of clearness, it being understood that *D* is always when balanced at the same potential as *C* with respect to the plus source. Current cannot flow from *E* or $E1$ into *A* or *B* under the assumption that *A B* at the moment is above earth potential; therefore the wire-to-earth capacities *Ka*, *Kb*, *Ka* 1, *Kb* 1 cannot unbalance the currents through the loading coils so long as the resultant capacities are balanced as previously stated.

We have now arrived at the conclusion that balancing the wire-to-earth capacities as distinguished from resultant capacities made up partly from wire-to-wire and partly wire-to-earth are not necessary from the theoretical point of view, and this is borne out by actual experiment where the source of current has no appreciable capacity to earth or no appreciable leakage to earth. But where the source has capacity or leakage to earth it may easily be shown that capacity to earth must be balanced to avoid interference from such circuits, or as an alternative a well insulated and balanced transformer having an electrostatic screen between the primary and secondary windings may be interposed between the cable and the faulty circuit. In practice unbalanced circuits are liable to be connected to a balanced cable unless the latter is operated through special transformers. For these reasons it is desirable to balance the earth capacities, and the following procedure should be adopted as a modification of the method already described. If the loading coil section contains 25 lengths of cable, tests should be made at the joints 1–2, 3–4, 5–6, and 7–8 for resultant capacities only. Select joints 1–2, 2–3, 3–4, together, and 5–6, 6–7, 7–8 together. Test 1–4 and 5–8 for earth capacities and resultant capacities, the latter being as a check only upon the accuracy of the previous testing and jointing. Select joint between 4 and 5 for earth capacities only. Lengths 9 to 17 will be treated similarly except that five sections will require to be selected together. Lengths 18 to 25 will be treated like lengths 1 to 8. The Sections 1–8, 9–17, 18–25 will be measured for resultant and earth capacities, and selections will be made for the former except in cases where the latter are large, in which case they should be taken into account. The earth capacities are measured by connecting the telephone to earth when the pair under test is connected to the bridge. The changes which the test values undergo when crosses are made are very simple. Crossing the wires of a pair merely changes the sign of the reading, and crossing pairs interchanges the magnitudes without affecting the signs. If the reading of *AB* is *U* and *CD* is *V*, then crossing *AB* and *CD* changes *U* into $-U$ and *V* into $-V$, whilst crossing pairs changes *U* into *V* and *V* into *U*.

(*To be continued.*)

SOME NOTES ON AMERICAN TELEGRAPHS.

By John Hume Bell,
Late of the Telegraph Section, E.-in-C.O., and Secretary of the I.P.O.E.E. before entering the service of the Western Electric Company, New York.

In the first issue of this Journal Mr. Donald Murray stated that "if some magic carpet suddenly transported a British telegraph engineer into a large New York telegraph office he would at first be dazed by the extraordinary clatter of the sounders." Although no magic carpet was employed in the transportation of the writer, the effect produced upon him on his first visit to the New York head office of the Western Union Telegraph Company was akin to that described above.

The public telegraph traffic of the United States is handled almost entirely by two large companies, the "Postal Telegraph" and the "Western Union." The latter is the older and larger concern, having about 25,000 offices in 21,000 separate cities, towns, and villages, and a wire mileage of approximately 1,500,000. According to the latest records over 90 per cent. of the entire revenue of this company is obtained from less than 2000 of the 21,000 places, and nearly 17,000 offices have an average monthly revenue of about £2 each, with a maximum of £10. Clearly the small offices have very little traffic, and it is only by co-operation with the various railroad and telephone companies, in whose premises many of such offices are located and by whose staffs the traffic is handled, that the existing telegraph facilities can be economically provided over so wide an area of country.

Small offices are linked up, sometimes as many as forty, in series on one circuit, termed a "way wire," and operated on the closed circuit system, as shown in 1. The necessary energy, usually drawn from dynamos, is provided at one or both of the terminal offices. On long circuits the total voltage may be as high as 350. At each intermediate office a few primary cells are required to operate the local sounder circuit.

Duplex circuits do not differ in principle from those used in Britain.

The line signals are sent out by an electrically operated pole-changer, the coils of which are joined in series with two operating keys and a low-resistance sounder. The second key is placed near the receiving operator, who uses it to ask any corrections he may require. The sounder is provided to enable the sending operator to hear his own signals. American operators have become so accustomed to send in this manner that the abolition of the practice would now be difficult. Nearly all operators have spent the first few years of their service in some small office where they were accustomed to hear their own signals when working the local "way circuits," and this is probably the origin of the practice. It is to be regretted, however, that no steps were taken to prevent the general use of sending sounders in large offices, where they are responsible for half the clatter referred to by Mr. Murray. Their provision involves considerable capital outlay and somewhat hampers simplification of local circuit connections.

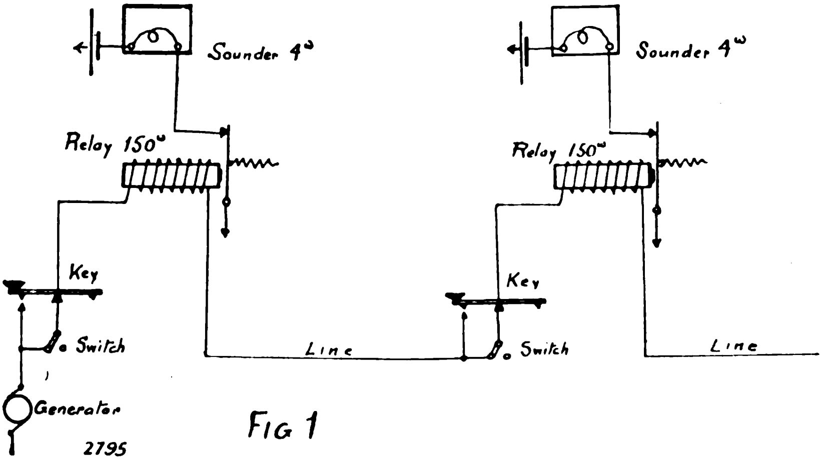


Fig 1

In the quadruplex system used by the Western Union Company two voltages only are needed, change in current strength being obtained by the insertion of resistance in the line circuit, and a leak path to ground, as shown in **2**. A definite ratio must exist between resistances *A*, *B*, and *C* in order to produce a current ratio of 1 : 3, 1 : 3·5, or 1 : 4, as may be required, and also that the total resistance to incoming signals may remain unchanged.

The following table, in conjunction with the lettering in **2**, shows the ratios which should exist:

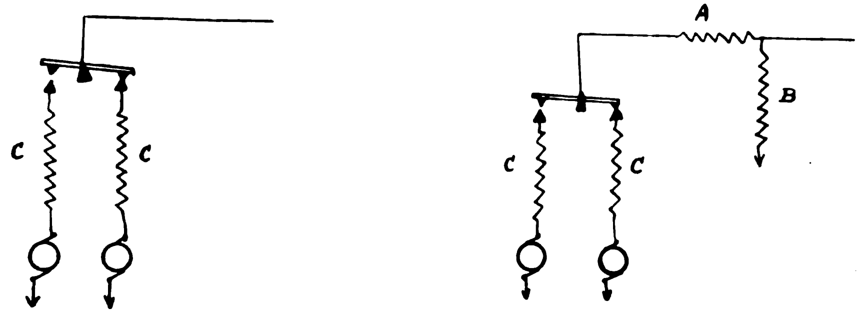
Ratio of current strengths.

1 : 3 . $A = 2C$. $A + C = 2B$

1 : 3·5 . $2A = 5C$. $2(A + C) = 5B$

1 : 4 . $A = 3C$. $A + C = 3B$.

Correction of the "B" side signals is effected by the use of an extra coil on the non-polarised relay, termed the "holding coil," connected in series with a condenser of suitable capacity as shown in 3. In the case of quadruplex repeaters this arrangement appears to offer an advantage over the British method of rectifying the signals at the "B" side sounder itself, as it obviates the need for two relays with their battery connections and resistance coils. A further advantage claimed for it is that it permits of uniformity in the local circuit connections (termed receiving legs) of both "A" and "B" sides of quadruplex and of duplex circuits. The desirability of securing such uniformity will be shown later.



B Side key depressed

B Side key at rest

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Fig 2

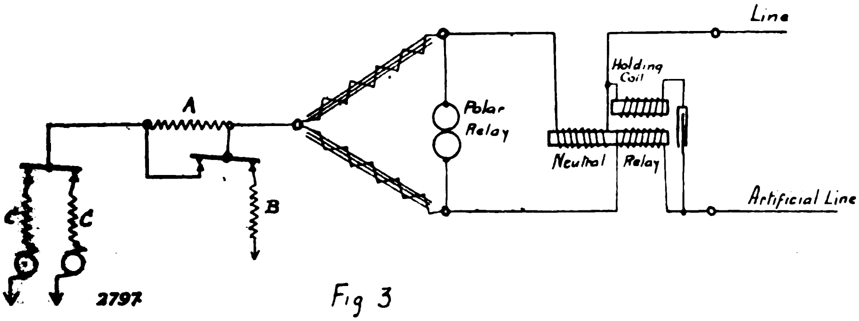


Fig 3

The pole-changer and the transmitter, which take the place of the reversing and incrementing keys, are operated electrically in the same manner as the pole-changer of the duplex. The electrical connections between these instruments and the keys and sounders at the operating tables are termed "sending legs."

The lay-out of the apparatus in large offices differs considerably from that usually followed in European offices. The main line relays, pole-changers, and duplex balancing apparatus are concentrated in one section of the office, and are attended to by a staff of specially trained men. In the Western Union New York office energy is drawn from dynamos located in the basement. The power leads come up to a series of busbars mounted on a mezzanine floor in one of the operating rooms. From these busbars taps are taken off through suitable lamp resistances to the various apparatus sets in the "balancing" room.

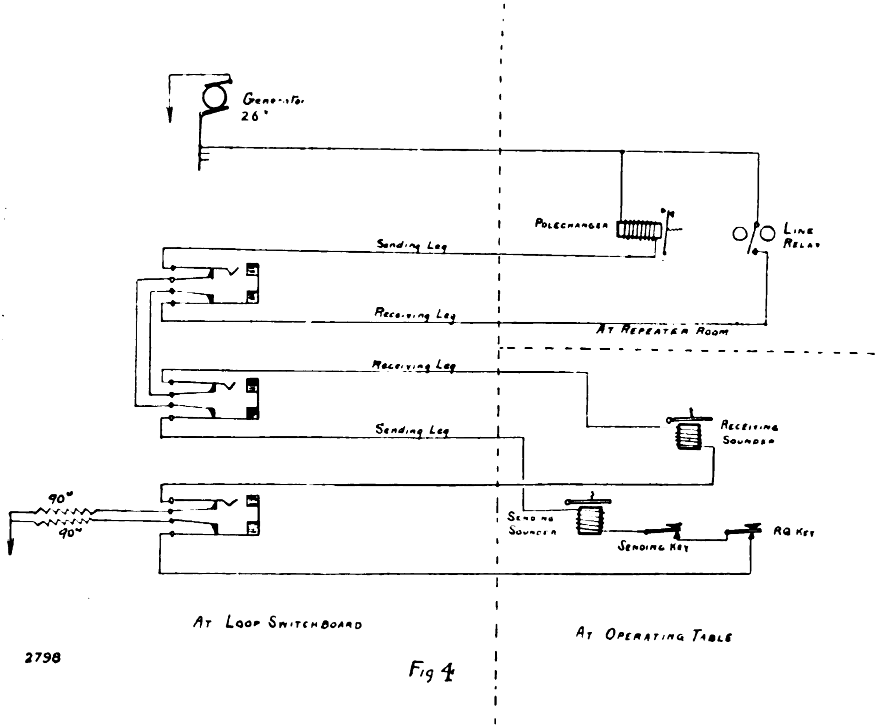


Fig 4

The sending and receiving legs of each duplex and quadruplex are led to a switchboard termed the "loop switchboard" and terminate on the outer springs of break jacks. To this switchboard are also connected the leads from the operating sets in the instrument room, terminating on the outer springs of another series of jacks, the inner springs of each corresponding pair of jacks being connected together as shown in 4. Circuit conditions are normal when no pegs and cords are in use. Any rearrangement of circuits in the operating room can be made by cross-connections at the loop switchboard.

A number of sending and receiving legs are provided between the head office and certain important branch offices within about one mile radius, and these "legs" also terminate at the loop switchboard so that any of these branch offices may readily be put in direct connection with any long-distance circuit. By means of what is termed a double loop repeater, several branch offices can be connected on the sending and receiving legs of a duplex circuit, and this is the general method employed for giving such important branch offices as the Stock Exchange, Cotton Exchange, and Sugar Exchange, direct communication with distant cities such as Galveston, Chicago, New Orleans, or Savannah. None of these branch offices separately may have sufficient traffic to warrant the exclusive use of a long-distance circuit, but for the joint use of several branch offices in the manner described, its provision is justified both on the score of economy and efficient service. The sending operator at each branch office has a listening sounder in series with his key which enables him to tell whether or not the line is being used by one of the other offices. Obviously there must be no squabbling as to priority amongst the sending operators, and none occurs. Operating regulations, which need not be enumerated here, govern the working of these circuits. The operators are specially selected men, and the records of traffic passing over these circuits show that a high standard of working efficiency is maintained.

Leased circuits are made up in similar manner to the main office circuits, *i. e.* by connecting up sending and receiving legs through the loop switchboard, the duty of maintaining balances and adjusting relays being performed at the head office.

The reason for having the connections of the "B" side of quadruplex circuits uniform with the local circuits of ordinary duplex and "A" side quadruplex is perhaps now apparent. Should a long distance circuit become faulty, communication can be promptly restored by transferring the sending and receiving legs to another circuit which is already balanced. Operators are not advised whether they are working on a duplex or the "A" or "B" side of a quadruplex, and it is to be hoped that the quality of "B" side signals is such as to enable the operators to remain in blissful ignorance.

An increasing number of operators make use of auto-dot keys, or, as they are more generally termed, "wig-wags" or "bug-senders." There is no doubt that by using these semi-automatic sending devices many men afflicted with cramp who would otherwise have been compelled to retire from the telegraph service have been able to continue as expert operators. 5 shows in diagrammatic form one type of "wig-wag" key. The key lever has affixed to it a flat spring upon which a sliding weight may be fixed at any position. In this manner the natural frequency of vibration of the flat spring can be altered to correspond to the speed at which the dots are to be made. Normally the lever occupies a central position, and the circuit through it is broken. Pressure on the key at one side causes a permanent contact to be made, and a dash signal of any desired length is thus made.

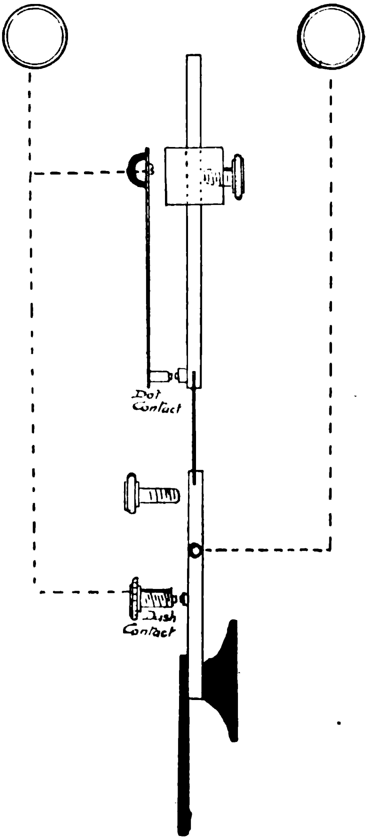


Fig 5

Pressure from the other side causes the spring to vibrate and to close a contact at each vibration, the number of dots thus made being determined by the operator.

Another machine which has helped to ease the lot of the American telegraphist is the typewriter. Even with the aid of an auto-dot key adjusted for rapid working a sending operator is unable to "run down" a receiving operator who makes use of a typewriter. The ease with which the typing is performed is in striking contrast to the concentration of attention which must be given by an operator transcribing in longhand with pen or pencil at a high speed.

It was customary in the past for operators to supply their own typewriters, and many devices were resorted to to render a machine unusable by anyone but the owner. One operator learnt to type on a machine with blank keys, another had the position of the letters on the keyboard considerably altered from the universal keyboard setting, whilst another went still further and had the position of the type characters altered, the keyboard remaining unchanged. Needless to say such freak machines were left undisturbed by unauthorised persons.

Some time ago the Western Union Company decided to furnish type-writing machines specially adapted for telegraph work, and thus relieve the operators of the cost of providing them. An order for ten thousand machines was placed with the Underwood Company, and most of these are now in service.

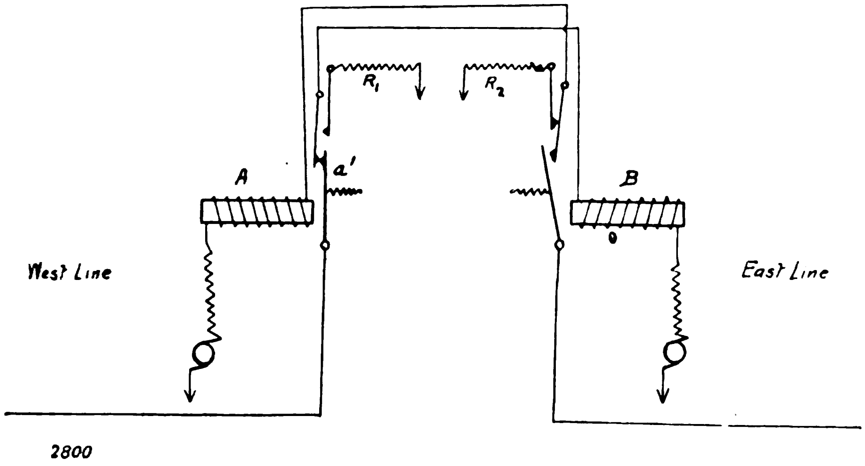


Fig 6

Some "way" circuits are so long as to necessitate the use of a repeater, whilst long leased lines and special newspaper circuits have frequently as many as three and four repeaters in circuit. Of closed circuit repeaters there is a large variety, and new types are still being designed.

6 shows the principle of one type of closed circuit repeater, of which there are several modifications. This may be classed as the "make-before-break" type. Normally both line relays are energised, the circuits on either side being closed. When any key on the west line is opened relay B is de-energised, its armature falls back and so breaks the circuit of the east line.

Assuming now that the resistances R_1 and R_2 did not exist, then as soon as the armature of relay *B* left its front contact the circuit through the winding of relay *A* would be broken, the armature a^1 would fall back and so produce a disconnection on both lines. The function of the make-before-break contacts on the relays and the resistances R_1 and R_2 is to ensure that during the release of one line relay a current of suitable strength will continue to flow through the other line relay, and by retaining its armature in the attracted position will prevent opening the line on which the incoming signals are being received.

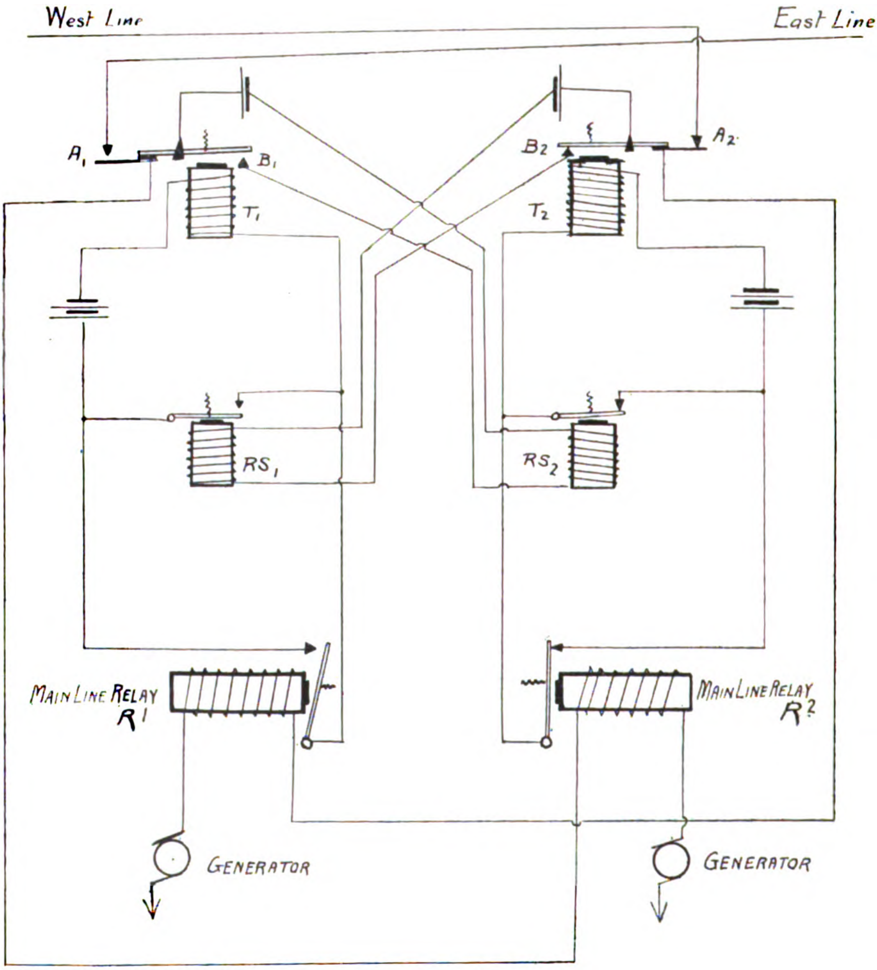


Fig 7

Such a repeater as that shown in **6** would work efficiently on a circuit having a good working margin, but it is doubtful if it would meet the severe requirements of a long line during periods of low insulation. On a long line disconnected at the distant end the leakage current passing through the line relay at the repeater may amount to 40 milliampères, whilst earthing the line at the distant end may increase the current to 45 milliampères only. Obviously the line relay at the repeater must be adjustable to pull up with 45 milliampères and to fall back when the current drops to 40 milliampères. Relays of the "make-before-break" type cannot meet such requirements so well as those with fixed contacts where the distance of travel of the armature is less. Consequently a repeater of this simple design has to give place to one which is somewhat more complicated.

One of the best known closed circuit repeaters in use to-day is that known as the Atkinson repeater. **7** shows the connections when the west line has been opened, thus allowing the armature of main line relay R_1 to fall back and open the local circuit which existed through transmitter T_1 and the front contact of relay R_1. Transmitter T_1 is thus de-energised and its armature is released. The contact at B_1, however, is broken before that at A_1, which has a flexible spring extension on the armature, thus permitting the release of the armature of RS_2 before the armature of main line relay R_2 falls back. In this manner the local circuit through transmitter T_2 is not disturbed by the operation of transmitter T_1.

It will be seen that in this repeater the line relay has a simple armature to actuate against a fixed contact. The transmitter with spring contact is operated in local circuit where sufficient energy is available to produce positive action. The operating margin is secured by the slight time lag which exists between the opening of two contacts, one fixed, the other a spring contact. The correct adjustment of these contacts and of the repeating sounders RS_1, RS_2, once obtained, the only adjustments required to meet varying line conditions are those of the line relays R_1 and R_2.

One noticeable feature of American conditions is the remarkably high insulation of aërial lines which exists throughout the greater portion of the year. During some experiments in which the writer was interested, an aërial circuit of nearly 500 miles in length showed practically no loss of current, the current at the receiving end being within 99·5 per cent. of that sent out.

ON DOCTORS' PRESCRIPTIONS.

By JOHN LEE.

THE story is told of a certain eminent bishop who wrote a villainous hand. On one occasion he dropped a little note to a friend in London, who, in turn, was unable to make head or tail of it. In sheer despair, the friend detached the episcopal heading from the note-paper, and took the remainder to the chemist round the corner. The chemist forthwith went behind the mystic fluted glass, mixed up a suitable bottle, coloured the contents an appropriate shade of scarlet, and charged him one shilling and eightpence. It was before the days of the so-called Drug Stores. When the bishop received the scarlet bottle, in due course, he was surprised. He remonstrated with his friend, who replied: "Your note was so hard to understand that I felt sure it was scientific."

Nowadays the medical profession shows some signs of changing its methods. It takes the lay people a little more frankly into its confidence. It has less faith than formerly it had in the efficacy of cryptic language as a cure for human ills. Consequently we all know a little more about ourselves, and our confidence has increased. We are less thrilled than we were at the sight of a prescription. The fluted glass has lost its terrors. "Potass." to us nowadays is "potassium," whereas once it seemed to be a personal reflection. The little curly things at the end of the lines, which once we dreaded as some sort of medico-artistic caricature of the shape of our pitiful legs, are known to be "grains" and "pennyweights" and other stages in the social scale of drugs. Indeed, so have we developed that even a Harley Street specialist has been known to write his injunctions in English, and to speak of "headache," an Anglo-Saxon word which has now found a secure place in medical language. It frequently appears even in learned medical journals.

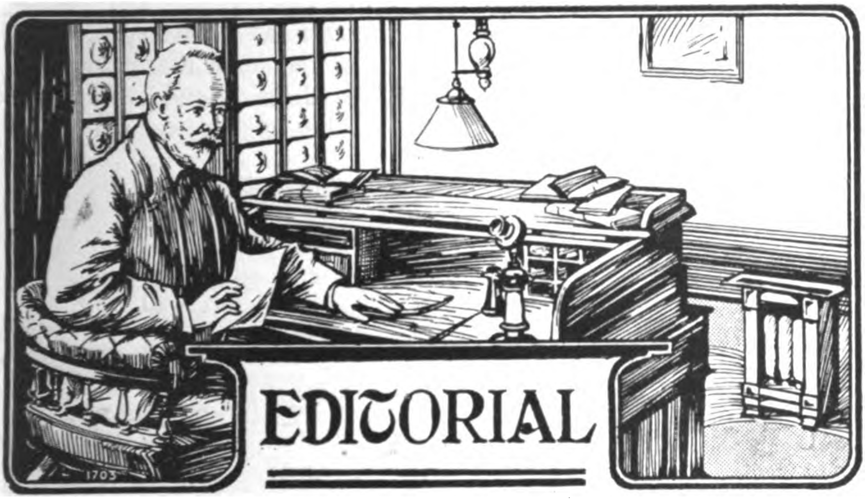
Lay people are well aware of their indebtedness to the medical profession. That profession is the most beautiful section of the Civil Service; whether or not it ever becomes a State medical service is a smaller question. High and low, rich and poor, owe to its research, its tenderness, its enthusiasm, the soothing of the brow of pain and the softening of the blows from the hand of Fate. But as the use of technical language has been modified our indebtedness has increased. Our medical adviser comes to be our friend and teacher. He is not now called in only at the crisis point. We visit him to talk things over. We consult him that we may continue in health. No longer do we divide our ailments into two classes, one to be treated by homely remedies, the other to be treated in Latin.

All the remedies are homely, frank, undisguised. There is now a less rigid demarcation between the professional and the lay mind. He knows more than we do, but in the application of his knowledge he asks for our co-operation. He advises; we administrate. He gathers from the store of medical knowledge of the world and puts it, in plain language, at our disposal. He does not resent our attempts at understanding; rather he explains at length. No professional jealousy bids him hide his thoughts in the language of mediæval monasteries, a tradition from the days when learning had secrecy for its main characteristic. He is not the less exalted, rather he is the more exalted, because he makes things quite clear to humbler and trusting minds.

To this greater frankness we respond eagerly. Ah, so *that* is the cause of our headache? Yes, we admit not his diagnosis merely, but his essay into causation. We have burned the candle at both ends, exactly as this our friend has stated. His grandfather would have handled our grandfather differently. In that age of mystery, the Victorian epoch, the medical ancestor would have beheld the lay ancestor with benevolence in his eye. With due pomposity—also Victorian—he would take to himself his pen of hardened steel and with its aid would have hidden bicarbonate of soda under hieroglyphics. And the trembling hand would have taken it to the Victorian druggist. So far all is deceit—well-intentioned and kindly and even affectionate. The real truth would only come out on the death certificate, which was a poor consolation to the man who once bore worthily the name of Patient. Nowadays the patient may suffer, but he does not suffer so acutely from *Ignoratio Causæ*. He knows. He is intimately acquainted with the organs and ducts and channels which have called loudly for treatment. He knows of his appendix—or, more accurately, he did know of it. The sacred secrecy has gone and we are all the better for it. We have burned the boats of our Victorian hypocrisy. Even in drawing-rooms " legs " and " livers " are mentioned, and we are unashamed.

So is Science the better for it. There is a missionary side to Science. It is not merely that knowledge should "grow from more to more" and that " more of reverence " may in us dwell, but that our lay reverence shall be based upon closer intimacy with research. Intensively all branches of science are developing, but there is a danger lest this intensive growth should be at the cost of extensive application. It is true that scientists need a language of their own for readiness of communication, a shorthand *ad hoc*. But in the communications—the missionary communications—to the wider arena of lay people, for whose behoof, after all, science is advancing, there is great need for simple direct language, for the sparing use of technical forms of thought and of technological expressions. The days of fluted glass and mystification are over, because our indebtedness is becoming so great that the common mind is irked and distressed by its failure to comprehend the fulness of meaning of contributions to its knowledge.

So, perhaps, in these pages, the lowly lay mind may make its appeal. Deep lies it in debt to those minds which give to it generously the rich fruit of patient research. But sometimes the fruit is over-rich, and mental digestion calls out for a similarly simple diet to that which the modern physician kindly gives to the sister digestion. The prescriptions which come to the awe-stricken mind are sometimes even more appalling than the prescriptions which came, a decade ago, to the shivering body. A reviewer said of Mr. Henry James's 'The Wings of a Dove' that it was so difficult to understand as to demand from the reader the contribution of a mind equally subtle and alert with that of the writer. No doubt such reading is exhilarating; no doubt, too, there is some sense of gratification in co-operating with a giant mind. But we are not all giants. Some of us are dwarfs, and we would fain be content to look upwards and to hear from below. Too frequently we are asked to jump upwards in order that we may meet the golden words halfway. If only those who have the knowledge and who have the generous temper which bids them disseminate that knowledge would bear our limitations in their minds, we should be even more appreciative than before, and the extensive application of science to the work of to-day would be facilitated and furthered.



EDITORIAL NOTES AND COMMENTS.

THE King has been pleased by Letters Patent under the Great Seal, bearing date the 12th inst., to appoint the Right Hon. Charles Edward Henry Hobhouse to be His Majesty's Postmaster-General during His Majesty's pleasure.—*London Gazette*, February 20th, 1914.

Mr. Hobhouse, who is a son of Sir Charles Parry Hobhouse, Bart., was born on June 30th, 1862, and is therefore in his fifty-second year. He was educated at Eton and Oxford. From 1892 to 1895 he sat for East Wilts, and since 1900 he has represented East Bristol. He was appointed a Church Estates Commissioner in 1906, Under-Secretary to the Indian Office in 1907, Financial Secretary to the Treasury in 1908, Privy Councillor in 1909, and Chancellor of the Duchy of Lancaster in 1911.

He is best known to the Post Office staff as Chairman of the Select Committee of the House of Commons which, in 1907, was appointed to inquire into the conditions of employment, etc., in the Post Office.

Mr. Hobhouse has assumed control of the Post Office at a time when two matters of importance are occupying considerable attention—we refer to the staff reorganisation arising out of the report of the Holt Committee, and to the revision of the telephone tariff. He is to be congratulated on the fact that, in dealing with the former, he will have the benefit of his experience as Chairman of the previous Committee, and also that, in attempting to solve the other problem—equally complex—he will be fully cognisant of the Treasury aspect of the matter.

As representing in some degree the Engineering Department of the Post Office we extend to Mr. Hobhouse a very hearty welcome, and in doing so we venture to express the hope that his term of office at St. Martin's-le-Grand—whether short or long—will be one upon which in due course we shall be able to look back with pride as having contributed both to the convenience of the public and to the welfare of all grades of the staff.

THE RT. HON. C. E. H. HOBHOUSE.

While feeling pleasure at the announcement of Mr. Samuel's promotion to the Presidency of the Local Government Board, Post Office Engineers—in whose operations and investigations Mr. Samuel has evinced considerable interest—are exceedingly sorry that the parting of the ways has come. Mr. Samuel came to the Post Office on February 15th, 1910, with a great reputation as an administrator, and he lost no time in enhancing it. During his period of rule as Postmaster-General many important developments and reforms took place, and a dozen are cited as being of especial interest to readers of this JOURNAL :

(1) Two new telephone cables laid between England and France.
(2) New telegraph cable laid between England and Germany.
(3) New telephone cable laid between England and Belgium.
(4) New telephone cable laid between England and Ireland.
(5) £6,500,000 spent on the development of the telephone system and a further sum of £10,000,000 voted.
(6) About 500 new exchanges opened.
(7) Automatic telephone exchanges introduced into Great Britain.
(8) Electric tube railway for the conveyance of mails in London authorised and about to be constructed.
(9) Erection of the Imperial wireless chain of stations authorised and commenced.
(10) The National Telephone Co.'s undertaking transferred to the State. Arbitration award of £12,500,000 as against £21,000,000 claimed.
(11) Engineering staff (all grades) increased from 7000 to 24,000.
(12) Engineering staff re-organised.

That so many important developments and changes should have come to pass in the short space of four years is indeed striking, and it is gratifying to be able to include in the list a revision of the engineering grades of the Post Office, which embodied a recognition by the late Postmaster-General of the value of the work done by Post Office engineers.

Mr. Samuel leaves the Post Office with the best wishes of the Engineering Staff.

The United States Post Office Department has followed the example set by the home administration, and the Postmaster-General has appointed a committee, similar to our Awards Committee, to adjudicate upon suggestions submitted to it by employees for improvements in the service. To obtain an award the suggestion or invention must be one that will clearly effect a material economy or increase efficiency. The sum of 10,000 dollars has been appropriated annually for this purpose; the maximum amount to be paid in any one month, or for any single suggestion, will not exceed 1000 dollars.

In our last issue Mr. Addey, in his valuable series of papers on "Alternating Current Calculations," described on p. 344 a method of measuring resistance and inductance which was devised by Mr. C. E. Hay, of the Research Section, Engineer-in-Chief's Office. As Mr. Addey had already gone into the details of the method and ascribed its authorship in an article on "Telephone Transmission," which appeared in vol. 5, he did not consider it essential to his purpose to indicate the source of the test in his later paper. We take this opportunity of awarding due credit to our versatile colleague, who, as everybody knows, is one of the greatest authorities on Wheatstone bridge measurements.

The Sixth Annual Conference of the Society of Post Office Engineers was held in London on February 7th, 1914, and following day.

On the eve of the Conference, a very enjoyable Re-union and Smoking Concert was held at the Tavistock Hotel, W.C. Nearly 200 Engineers and friends in the Service assembled, and proved that, although always busy men and oft overworked, Post Office Engineers are not yet incapable of thoroughly enjoying a concert remarkable for its rousing choruses.

FROM WITHOUT AND WITHIN.

TRADITIONS die hard, and a popular delusion lives not infrequently to a green old age unless or until some exasperated sceptic, with a kick of reason, tumbles it—a spent scarecrow—into a convenient furrow; at which some rooks will still caw.

It is nearly half a century since Dickens died, and most of the evils of the day which he satirised have followed him. Schools of the Yorkshire type are no more; imprisonment for debt has been abolished, body-snatching is extinct, and electioneering methods have wholly changed. But the Circumlocution Office perennially blooms in the fancies of the severely facetious, visioning enough of red tape "to stretch in graceful festoons from Hyde Park Corner to the General Post Office"; the quip passing us innocuously by reason of the great novelist having particularised our own little sphere of public service as the end and not the originating point of this decorative scheme.

Still, we of the Telephone Branch cannot but be conscious of the winging of more modern shafts, from many quarters, which being meant, at least, to sting, do here and there occasion us some inconvenience or chagrin.

With scarcely more than two years of Post Office life behind me and a receding background of twenty-nine in the National Telephone Company's service, I may perhaps still claim to possess a fresh mind as to the newer conditions, while retaining undimmed the recollections of former experience. It may not, therefore, be out of place at this juncture to review some actual facts as one has found them in comparison with one's preconceived notions of life in a State Department. And at the outset I have to express entire concurrence in the view of the wise man who once said that if we were all stripped we should be found to be very much alike.

To clear the ground, one or two propositions have to be accepted —as, for example: Both the Post Office and the Telephone Company had, formerly, extensive telephone systems in London; each execrable according to some; to others endurable; superlative praise only to be conferred posthumously. Given equality in worth of raw material, it follows that any flaw in the manufactured article must be purely a personal matter, *i. e.* it must be the result of want of skill, or defects in organisation or apathy or carelessness, what you will. Now, prior to the amalgamation of the two systems, complaints by subscribers (and they ought to know) of the service were about equal on both sides, and it may therefore be assumed that the management and staff were equally good, or, if it be preferred, equally bad.

After these premises comes the puzzle. Since those halcyon days, if we are to believe the newspapers (and, like Mr. Crummles, I can't think who puts these things in), the Service has not steadily, but by leaps and bounds, deteriorated; although, be it remarked, the commercial world seems to have rubbed along as though nothing had happened. How is this downfall to be accounted for? Can it be possible that the two staffs, lost in contemplation of each other's virtues, have forgotten their first duty, or that in chivalrous emulation of the Black Prince each has clamoured to bestride the humble pony to allow the other to shine resplendent on the full-grown steed; and thus between the two both have come to the ground? Mere suggestions, of course, but possible.

I can think of one more explanation, and a plausible one. While the "National" flock changed their pasture the shepherds remained behind; the shepherdless sheep, therefore, bringing plenty of wool with them but no brains; straying into the company of other sheep, whose shepherds with this additional charge had an insufficiency of brain to go round; reminding one of the miller with two windmills, who dismantled one because there was not wind enough for both.

I am not quite certain whether some of us of the transferred staff were not, prior to our migration, fearful that in the Post Office we should find no further scope for our bounding vitality, and that all we could hope for was that, in due time, we too might learn to take our ease without qualms; howbeit, the more sanguine may have aspired to infuse somewhat of their enthusiasm into the body of that effete and hoary institution.

But, if so, our nightmare was brief, and we awoke relieved and sobered. For, speaking for myself and others of my old colleagues with whom I have discussed the subject, it took very little time to realise—some of us, I fear, with mixed feelings—that the standard of work demanded, and prevalent, in the Post Office is far higher, man for man, pay for pay, and age for age, than that formerly expected of us—the more limited scope of the Company not providing so many outlets for promotion nor for interchanges of duties, and thus men might, and did, go on for years ploughing and re-ploughing the same furrow, narrowing their utility, and learning little of what was going on around them. The judgment and reliability, the initiative and sense of responsibility displayed in the work of comparative juniors with whom I have come into contact during the past two years have been to me a continual source of wonder. It is not a case of abnormal ability here and there, but of an all-round plane of efficiency; and what is in the green wood is at least to be found in the dry.

There are many reasons for this high level, but possibly that which outweighs all others is that a critical public expect it, perhaps unconsciously, and what the public want they usually get. What, of course, the public do not always recognise is that thoroughness is costly, and that as time is usually the essence of value, we must be allowed enough of it in which to deal adequately with their requirements. Speaking of my particular sphere, I have been very much impressed with the complete sifting which takes place every time the complaint of a telephone subscriber has to be investigated. Those, and they are many, who imagine that these things are treated lightly or with indifference, would be astonished at the immense pains taken to get at the core of every difficulty or irregularity. Nothing is slurred over or evaded, and the stamp of finality is not affixed to the accumulated documents until a first-hand confession of the original sin appears among them in all its bare simplicity. Then all else is brushed aside, and the public are made acquainted with the plain unvarnished truth.

All this spells individuality, and creates that feeling of personal responsibility which seems to me to have so marked an effect on the tone of work in the Post Office.

With all the ramifications of such an enormous business as ours, investigations of any importance are necessarily prolonged; but to show that even such well-regulated concerns as railway companies (where Time would surely expect to be well served) are not exempt from what the man in the street might mistake for dilatoriness, a little example may give us a crumb of encouragement. A year or two ago a piece of old furniture was delivered to me damaged in such a way as to completely destroy its value. I submitted a modest claim with full particulars, and went about my ordinary affairs. Two months afterwards the station-master presented me with half a sovereign, and I wondered what had happened in those two months, how many officials and employees had been concerned, among what great company this atom had wandered, through what machinery it had passed to emerge refined gold, and how relieved everyone must have been to be rid of it at last.

Soon after my entry into the Post Office the need for a new kind of care was forcibly brought home to me by a dreadful apparition in one of the daily papers, namely, the publication of a letter of my own drafting. Careful scanning fortunately revealed nothing to blush at; but for some time after my daily repast of correspondence possessed me with a feeling something akin to the man who, dining in unaccustomed company, is embarrassed with a fear of committing himself by the mismanagement of an unwonted profusion of knives and forks. I merely mention this incident as emblematic of habits, striking to a newcomer, and peculiar to a public department, which one has to acquire to preserve the expectant tone and avoid obloquy. It is a small matter in itself, but indicative of the wariness with which every branch of the Service, in full publicity, has to tread its way, whether in correspondence, pole-planting, or stores-purchasing; and circumspection in walking is not conducive to speed.

It seems a little unreasonable to imagine that men—and women, too—having stepped on to the lowest rung of the ladder through the exercise of their brains, should suddenly abandon that medium of success, and embark for evermore on a system of *laisser faire*. And yet this is no uncommon view from outside, as ridiculous as it is unfounded, because it carries with it the theory that a qualifying examination is promulgated merely to satisfy the curiosity of the authorities on the subject of the competitor's past educational history, and not as an earnest of what may be expected of him or her hereafter. I have even heard it said that as amateur horticulturists, artists, musicians and writers we leave nothing to be desired, but that from a business point of view the real goal of the civil servant is his pension; this being the great secret why the Post Office is crowded with mediocrity, while every commercial concern around it puffs with energy. All I can say is, that I have never yet met the youth or maiden who, at the age of seventeen or thereabouts, worried or troubled themselves as to what is looming ahead for them at the age of sixty or sixty-five.

But I can also say this: that coming into the Post Office, a matured outsider, I have discovered by degrees that there is as much zeal, as much earnestness, as much devotion to duty and pride in good work among both sexes within as without. I find the same sacrifice of private leisure, the same individuality with at least as much recognition thereof as in my former experience. And so far as I have come into contact with other branches of the Service than my own, the same conditions appear to prevail. Wherever and whenever two or three officers foregather, whether in hotels or railway carriages, or even for social enjoyment, business topics are pursued with almost disgusting persistency.

A reproach frequently levelled at the Telephone Service is that the business is not run on commercial lines, and the generally adduced reason is that the *personnel* has had no commercial experience or training; but I have never been able to discover exactly what those "lines" are. Now, the vulgar acceptance of the meaning of the word "commerce" is, I believe, to buy in the cheapest market and sell in the dearest, and as my earliest experience in business life was not wholly unconnected with ship-broking and the coal trade, with a seasoning of the Custom House (where the cashier evinced a very commercial abhorrence of light gold), I may lay claim to have fitted myself to an unusual degree for a telephone career, and whatever modicum of success I have achieved in that quarter was no doubt presaged in my three years' sojourn in a strictly commercial concern in the neighbourhood of Billingsgate.

Strange to say, the knowledge I then gleaned of tonnage, freightage and pit and market prices seemed to have no bearing whatsoever on the easy-going system of twenty-pounds-a-year-or-no-telephone method with which I became subsequently acquainted. And, stranger still, I find no essential difference in the means employed by honourable men in providing a public service, whether shareholders, ratepayers or taxpayers have to be considered. Outside an unalterable tariff, which in our case is identical with that of a railway or gas company, I find the same spirit and elasticity of concession and fair-dealing prevalent in a Government Department as under a Board of Directors. If to run a business on commercial lines is to extort the uttermost farthing without remorse, we are a long way from the ideal, but if it mean the welfare of the community, then my poor powers of observation are utterly at fault if I have not discerned that our whole course moves continually in that direction.

Besides, I cannot, for the life of me, see what special commercial apprenticeship is undergone by the officers and employees of such public services as gas, electric light, tramways, railways, etc. (some of them run with conspicuous success) which is not attainable in the Post Office. For two years I have been trying to discover whence and how comes that benumbing blight which hearsay fastens upon the intelligences and business consciences of every man and woman whose misfortune it is to become a civil servant, and, so far, I am baffled; though at times a shudder passes through me when my ill-success suggests the horrible thought that I, too, may have taken the insidious disease without knowing it. Especially when I recall the expressions of condolence and commiseration showered upon me by sympathetic friends on hearing that my talents would henceforth lie buried in the precincts of St. Martin's-le-Grand—possibly associating that saint with his neighbouring brother, Bartholomew, and viewing the institution named after him as a Home for Incurables.

Before the days of motor traction, one might often see a heavily laden 'bus lumbering laboriously up Ludgate Hill. The horses who drew it were not fiery thoroughbreds, but with their necks well in the collar, and encouraged by the judicious urging of a driver mindful of passengers of varying temperaments, they did their best. And they usually got to the top. EUSTACE HARE.

HEADQUARTERS NOTES.

COMMITTEE ON HIGH-SPEED TELEGRAPHY.

THE Postmaster-General has appointed a Committee to inquire into the systems of high-speed telegraphy and to report thereon. It consists of: Captain Norton, M.P., Assistant Postmaster-General (Chairman); Sir John Gavey, C.B., past president of the Institute of Electrical Engineers; Mr. John Lee, Traffic Manager, Post Office Telegraphs; Mr. W. M. Mordey, past president of I.E.E.; Mr. A. M. Ogilvie, C.B., Third Secretary, G.P.O.; Mr. W. Slingo, M.I.E.E., Engineer-in-Chief, G.P.O.; Mr. A. B. Walkley, Assistant Secretary, G.P.O.

Anyone desirous of giving evidence before the Committee should communicate with Mr. G. O. Wood, Secretary's Office, G.P.O., who has been appointed Secretary to the Committee.

TELEPHONE EXCHANGE DEVELOPMENTS: C.B. MANUAL.

Since the last issue of the JOURNAL, orders have been placed for the equipment of new manual exchanges at Truro, 260 lines; Weybridge, 1380 lines; Wrexham, 460 lines.

Installation of equipment has been commenced at Altrincham, extension, 300 lines; Birmingham (Central), extension, 4600 lines; Birmingham (Midland), extension, 460 lines; Birmingham (Victoria), extension, 140 lines; Worcester, extension, 320 lines.

Installation of the following equipments has been completed at: Mansfield (New Exchange), 640 lines; Chester, extension, 840 lines; Doncaster, extension, 280 lines; Ealing, extension, 900 lines; Harrods' (P.B.X.), extension, 180 lines; Kingston, extension, 540 lines.

The following new exchanges have been opened:

Exchange.	Date of opening.	Number of subscribers' lines.	
		Exchange equipped for	At date of opening.
Helensburgh	6 : 12 : 13	480	371
Attercliffe	6 : 12 : 13	480	160
Llanelly	17 : 12 : 13	400	310
Victoria (London)	24 : 1 : 14	8100	5285

AUTOMATIC TELEPHONE DEVELOPMENT.

Paddington Exchange.—An order has been placed with Messrs. Siemens Bros. for automatic traffic distribution to twelve "A" positions, Nos. 104 to 126, for originating calls from 1000 subscribers,

Official Switch.—An extension of 150 lines has been completed. bringing the fitted capacity up to 650 lines.

PROTECTION FROM ELECTRIC LIGHT AND POWER CIRCUITS.

Important modifications have recently been made in the Department's requirements for the guarding of overhead electric lighting and power circuits. Hitherto these power circuits have been guarded by means of independent guard wires, earthed at each end, and the arrangement of the wires in respect of overlap and vertical distance has followed exactly the requirements of the Board of Trade for guard wires on electric tramways.

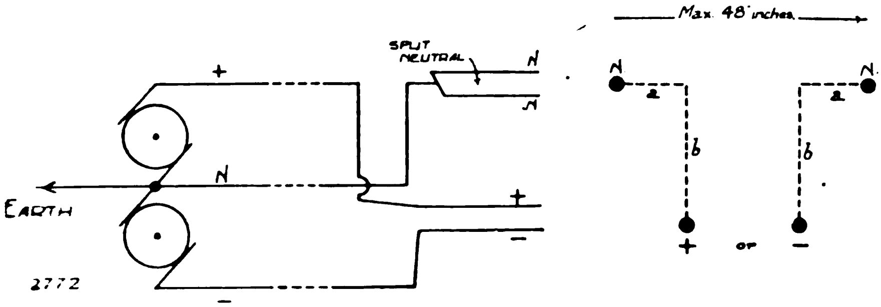
The Department is now prepared to accept an arrangement of the *current-carrying* wires of any electrical power system not exceeding 650 volts, continuous current, or 250 volts to earth, alternating current, provided that the earthed or earthed neutral wires of the electrical system act as guard wires.

For instance, in a 3-wire continuous current system, the neutral conductor would consist of two wires, *i.e.* split neutral, and for a guarding arrangement to protect telegraphs crossing above the power wires the arrangement would be as depicted in the figure.

The vertical distance *b* must be not less than 8 inches, and the overlap *a* must be not less than half the vertical distance *b*, whilst the maximum separating distance between any two earthed wires must not be greater than 48 inches.

For example, if *b* is 24 inches, then *a* must be not less than 12 inches.

The use of the neutral or earthed conductors, as guarding, has two advantages:



(1) If a telegraph wire falls across the neutral wire and an outer, the short-circuit conditions seem reasonably certain, and the present difficulty in regard to the value of independent earth connections for guard wires is overcome.

(2) The neutral wires, being part of the current-carrying system, will probably be efficiently maintained.

DISTRICT NOTES.

LONDON.

Victoria Transfer.—Many months of patient work were brought to a climax at two o'clock on the afternoon of Saturday, January 24th, when the transfer of some 9000 junctions and subscribers' lines, serving 14,000 stations, including the House of Commons, the War Office, Admiralty, and all the principal Government offices, was effected in the space of some fifteen seconds. The new switching plant is in a new building which has been erected by the Office of Works in Greencoat Place, near Vauxhall Bridge Road, and not far from Victoria Station. The new plant has been provided by the Peel Conner Telephone Works, Ltd., and is of the 40-volt No. 1 Common Battery type, similar to that provided at the Avenue Exchange, but in this case without ancillary lamps and jacks. In accordance with the usual practice in such cases all the working circuits had been "T'd" to the new Exchange at points outside the old Exchange. The connection to the apparatus at the new Exchange was complete except for the fact that the springs of the cut-off relays were held apart by small insulators. These insulators were connected together by short lengths of string, and the lengths of string were yoked together by tens and by hundreds and brought to suitable points, where string handles were provided so that one pull would remove a large number simultaneously. At the old Exchange broad tapes had been run down behind the heat coils on the main distributing frame, and these also were yoked together and provided with handles so that when the critical moment arrived they could be pulled out, and thus simultaneously the disconnection from the old Exchange and the connection to the new Exchange might be effected. Half of the junction circuits were transferred at 1.30 p.m., and at the same time half of the operators took up their positions in the new Exchange. At 2 p.m. the officers in charge of the transfer work were in communication by telephone and each gave the word " pull." At the old Exchange fifteen men stood in readiness along the M.D.F., and at the word they pulled vigorously, producing a Maxim-gun fusillade as the heat-coils flew out of the retaining springs. At the new Exchange six men served for the quieter operation of withdrawing the insulators, and the transfer had been effected.

The new building is in the form of a hollow square with one side missing, and the switch-room has the same conformation. Although it is a vast improvement upon its predecessor and boasts a polished parquetry flooring, the existence of two right-angles prevents one obtaining a clear view of it at any point, and the line of sight in every direction is unfortunately broken up by centre pillars. In this respect, therefore, the Victoria switch-room is inferior to Gerrard, Regent, Paddington, and Park, in all of which a clear, unimpeded view is obtainable. On the other hand the lighting is exceptionally good, and the clerestory roof provided at Victoria is a considerable improvement on the arrangement at Park, which has frequently been referred to as being of the swimming-bath variety.

It is pleasing to be able to state that the new Exchange has, during the week succeeding the transfer, taken up the functions of its predecessor with the utmost smoothness, and the successful completion of the work was recognised by the then Postmaster-General, Mr. Herbert Samuel, who issued to all concerned an expression of his satisfaction.

An official inspection by the Westminster City Councillors took place on Friday, February 27th, and a copy of a condensed description of the Exchange was given to each visitor.

EXCHANGE EXTENSIONS.—The work of converting the cord circuits on the "B" positions at Central Exchange for keyless working is now completed.

Museum Exchange is nearing completion. The bulk of the construction work is finished, and the lengthy process of testing out is in hand.

Extensions to the equipment are in hand at Brixton North, Palmer's Green, Stratford, Streatham, and Wanstead.

Information desks are being installed at Finchley, Mayfair, Park, and Willesden.

A private branch exchange of eight sections for the War Office is being provided.

NEW TELEPHONE LINES.—During the thirteen weeks ended January 27th, 1914, 4967 exchange lines, 3194 internal extensions, and 253 external extensions were completed. In the same period 3083 exchange lines, 1989 internal extensions, and 209 external extensions were recovered, making a net increase of 1884 direct lines, 1205 internal extensions, and 44 external extensions; approximately 5196 removals of exchange circuits were carried out for subscribers.

NEW LONDON ENGINEERING DISTRICT HEADQUARTERS.—Building operations were commenced on the new Denman Street offices on February 3rd, and rapid progress on the excavation work is now being made. The contractors are Messrs. James Smith and Son, of Norwood.

NOTES FROM THE LONDON SECTIONS.

Central Telegraph Office.—The installation of house tubes referred to in a previous issue is nearing completion, and five of the eleven tube tables in the galleries will be brought into use by the time this is in print. Two tubes which have been in use for some months have given great satisfaction. The displacement of the old lead tubes has resulted in the recovery from under the floors of about 80 tons of scrap lead. It will be remembered that the new brass house tubes are being run in parallel lines under the ceilings.

On completion of the house tube portion of the work, all the tubes in the Central Hall will have to be re-arranged and double slide switches substituted for the present old-form valves. This work will be attended with some difficulty, as the tubes must be kept working during the transition stage.

Official automatic switch.—The original capacity of the automatic switch has been exhausted, and an extension of 200 lines is nearing completion. In order to obtain space for this extension it has been necessary to re-arrange the rooms in the basement, part of the linemen's room being appropriated, and this entailed the removal of a wall which formed one of the main supports of the building. The manual portion of the automatic equipment is about to be removed from the G.P.O. West to the Central Exchange. Extensive re-wiring in connection with the house bell system in the G.P.O. North and G.P.O. West is in progress. Some 300 circuits are involved. The old system was installed by the Office of Works when the building was originally erected.

North section (external).—The laying of duct work from Harwar

Street to Broxbourne in connection with the London to Ware trunks and the fitting of several new pattern loading coils for the proposed trunk cable has been commenced.

South section (*internal*).—A spring wire message-carrier has been installed by the Lamson Company at Sydenham for the purpose of conveying fault dockets between the switch-room and the test-room, the object in view being the reduction of the duration time of faults.

Centre section (*internal*).—A new three-position multiple private branch exchange has just been completed and brought into use at the House of Commons.

West section (*internal*).—This section has now the honour of including the largest private branch exchange in London, and therefore in the United Kingdom. It is situated in the gigantic stores of Messrs. Harrods, Brompton Road, S.W. A recent extension has increased the installation, so that it now consists of 10 sections of the C.B. No. 10 type equipped for 480 extensions and 120 exchange lines. At present 84 exchange lines—47 in-coming and 37 out-going—and 314 extension lines are working. The power plant recently renewed consists of two batteries, each of 22 volts with initial capacity of 420 amp. hours, 1 D.C. motor and 1 power switchboard. Orders are received both day and night, and on December 24th, 1913, the traffic broke all previous records, the total number of calls in-coming, out-going and internal exceeding 10,000.

A Lamson wire-carrier similar to that referred to in connection with Sydenham has been installed at the Ealing Exchange. The cost of these carriers is, of course, much less than that of the pneumatic tubes, and their performances will be carefully observed.

OUR ANNUAL GATHERING.

The second annual gathering of the staff and friends will take place on April 4th, at the Holborn Restaurant, and, as on the previous occasion, it will consist of a tripartite function, including a dinner, a concert, and a dance. After the dinner the dance and the concert will proceed simultaneously in the King's Hall and the Throne Room respectively, and in this way an effort is made to cater for all tastes. So signal was the success achieved in connection with the 1913 re-union that there are already indications of a very large attendance on this occasion. A hearty welcome is extended to officers in sister-branches of the service, and tickets at 4*s*. 6*d*. (single) and 8*s*. (lady and gentleman, or two ladies) can be obtained from the Hon. Secretary, Mr. A. Wright, Battersea Exchange, Lavender Hill, S.W.

SOUTH LANCS. DISTRICT.

Since the last issue of the JOURNAL, 23 miles of duct and 16 miles of cable have been laid for local lines, and 24 miles of duct for main lines.

Contracts have been placed as follows:

	Ducts.			Cables.		
	£	s.	d.	£	s.	d.
Manchester, Bolton	8000	0	0	14900	0	0
„ Burnley	10000	0	0	16000	0	0
„ Rochdale	4500	0	0	6000	0	0
Liverpool, St. Helens	——			10500	0	0
Atherton (local)	1000	0	0	——		
Liscard „	1200	0	0	——		

The work at Manchester City Exchange which was being done by contract has been completed.

A number of local development schemes have been authorised under the Annual Contracts for underground works to completion; this will amount to some thousands of pounds. This work is being carried out by the British Insulated & Helsby Co.

SOUTH MIDLAND DISTRICT.

Since the formation of the District on October 1st, 1912, we have had to face the erection of over 6000 poles and over 7000 miles of wire. These figures represent main works only. The following summary shows roughly the work which has been performed in twelve months, *i. e.* from October 1st, 1912, to September 30th, 1913.

Miles of wire erected	4600
Number of poles	3600
Exchanges fitted and opened	14
Rental (P. W.) installations	90
P. W. stations	300
Fire-alarm installations	15
Exchange line stations	2600
Call-office stations	110

The mileage of wire and the number of poles is exclusive of work done in connection with the ordinary increase of subscribers' stations, removals, etc.

In addition to this about 41 miles of pipework and 25 miles of cabling in short sections have been carried out. This is, of course, apart from Main Cabling Schemes and Development Scheme Underground Works. Of the latter 22 schemes have been put in hand and are in an advanced state, comprising roughly the laying of 99 miles of pipe and 187 miles of cable containing 6500 miles of wire.

In connection with main cabling schemes, the trench mileage assumes the large total of 133 miles, with a pipe mileage of about 170 miles and a cable mileage of 25,000 wire miles.

The trench work has been completed. These figures include the portion in this District of the following schemes:

London, Watford, St. Albans, Aylesbury.
London, Slough.
London, Coventry, Birmingham.
London, Weybridge, Guildford.

There is little doubt that further extensions will be required in the very near future.

INSTITUTION NOTES.

COUNCIL MEETING.

A Meeting of the Council was held in Bristol on February 24th and 25th.

Membership.

The Secretary reported that during the present Session the following increases in the membership had taken place: 100 engineering, 32 clerical, 17 foreign and colonial.

In addition to the above, 254 associates had been enrolled, and the South Midland, South Lancs., North Midland, North-Western and Irish Centres were to be congratulated on their share in this excellent result of the Session's work.

Papers Submitted for Printing.

The Secretary reported that the following papers had been printed and would be issued immediately:

"Directive Wireless Telegraphy." F. Addey, B.Sc.
"Parallel Distribution." E. A. Pink.
"Manchester Fire-Alarm System." R. Nimmo.
"Low-Pressure Hot-Water Heating Systems." T. Monaghan.
"Correct Time." H. Myles Hook.
"Overhead Wire Construction." A. P. Trotter.

In addition to the above it has been decided to print the following:

"Alternating Current Measurement." C. E. Hay.
"Stone-Throwing Prosecutions." W. H. Powning.

Other papers were under consideration by the Council.

Medal Awards—Session 1912–13.

The Council awarded the following Institution Medals for papers read during the Session 1912–13.

Senior Silver Medal to Mr. C. E. Hay for his paper entitled "Alternating Current Measurement."

Senior Bronze Medal to Mr. F. Addey, B.Sc., for his paper entitled "Directive Wireless Telegraphy."

Junior Silver Medal to Mr. H. Myles Hook for his paper entitled "Correct Time."

Junior Bronze Medal to Mr. T. Monaghan for his paper entitled "Low-Pressure Hot-Water Systems."

The Council attended a meeting of the South-Western Centre at Bristol, at which Mr. Tremain read an interesting paper relating to his early experiments with loading coils.

The Chairman, Mr. W. Noble, presented Institution Medals, 1911–12, to Mr. R. Nimmo and Mr. E. A. Pink for their papers on the "Manchester Fire-Alarm System" and "Parallel Distribution" respectively.

T. SMERDON (*Secretary*).

LOCAL CENTRE NOTES.

LONDON CENTRE.

CONSIDERABLE interest was manifested by members of the Traffic Branch in the reading of Mr. B. O. Anson's paper, "The Elimination of Waste in Telephone Plant and Operating," which took place at the December meeting. Mr. A. M. Ogilvie honoured the meeting with his presence, and was accompanied by Mr. L. T. Horne.

Mr. Ogilvie took part in the discussion, as did also Mr. J. Stuart Jones and Messrs. Pink and Dives, of the General Manager's staff.

In January Mr. Hill gave his paper on "The Loading of Aërial Lines," and the discussion which followed proved so interesting that it became necessary to adjourn the same until the next ordinary meeting in February.

On January 20th a special meeting was held to hear Mr. A. P. Trotter, of the Board of Trade, on the "Erection of Overhead Wires for Medium and Low Pressures." Several gentlemen well known in the commercial world accepted the Committee's invitation to be present, and took part in the discussion. Mr. Trotter's paper has already been set up in type, and should be in the hands of members by the time they receive this number of the JOURNAL. Mr. Trotter read his paper subsequently at a joint meeting of the Institution and the Yorkshire Local Centre of the Institution of Electrical Engineers at Leeds.

The President occupied the chair at Mr. Trotter's meeting, and presented the Senior Silver Medal of the Institution to Mr. B. O. Anson for his paper on "Machine Switching in Telephony."

The arrangements for the reading of Mr. L. B. Turner's paper, which was to have taken place at the February meeting, not having been completed in time, the reading of the paper has been postponed to a future date, probably one in April. The meeting, however, was taken by Mr. F. Addey, who gave a lecture on "A Modern P. O. Wireless Station," illustrated by lantern-slides. The station described is the one just recently erected at Malin Head in Ireland. Mr. J. G. Hill occupied the first portion of the meeting with a reply to the criticism on his paper. The Controller of Stores, Mr. Morgan, and the Assistant Controller, Mr. Allen, were present.

In December a very interesting visit to the Neasdon Power Station took place by the courtesy of the Metropolitan Railway Co.

The Committee has much pleasure in acknowledging on behalf of the Institution a presentation by Sir John Gavey to the Central Library of a series of 'Journals of the Franklin Institute' and a series of the 'Royal Engineers' Journal.' W. G. O.

SOUTH MIDLAND CENTRE, READING.

With pleasure we have to record a very successful Session. At our first meeting two representatives of the Engineer-in-Chief, Messrs. Sinnott and Reid, were present; at the second meeting Mr. H. Brown; at the third meeting the whole of the Council; and at the fourth meeting the President.

From causes over which we have no control the published programme had to be slightly modified, and the following are the particulars of the meetings held since the Centre was formed:

First meeting, April 29th, Mr. Whitehead: "London–Aylesbury Duct Scheme; Sykes Ducts, and Laying thereof." Present, 86 members.

Second meeting, September 30th, Mr. Atkins: "Faults." Present, 64 members.

Third meeting, November 18th, Mr. Beasley: "Development Schemes." Present, 66 members.

Fourth meeting, December 15th, Mr. Hall: "Works Orders"; Mr. Shorter: "Organisation of a Sectional Engineer's Office." Present, 59 members.

Fifth meeting, January 20th, Mr. Moody: "Organisation of Maintenance Work." Present, 35 members.

Sixth meeting, February 25th, Mr. Macpherson: "Workmen's Classes"; Mr. Eaton: "Messenger Boys' Classes." Present, 38 members.

The discussions were particularly exhaustive and well maintained at each meeting, and on three occasions had to be curtailed owing to the room being wanted.

It is interesting to note the keenness of the transferred Staff in all matters affecting the Institute, and it is hoped the few eligibles who are not now members or associates will become members at a very early date.

We may congratulate ourselves on the fact that practically every member of the Inspector's Class has enrolled.

SOUTH LANCS. CENTRE.

The fourth meeting of the Session was held at Manchester at 5.30 p.m. on January 5th; seventy members and visitors present. Mr. G. H. Vaughan delivered a lecture on the "Experiences of a Telegraph Engineer in South America." A large number of excellent lantern-slides were shown, and the lecture was highly appreciated. The fifth general meeting was held on February 2nd, when Mr. T. Cornfoot read a paper on "Traffic." The paper was well received, and an interesting discussion followed.

NORTH-MIDLAND CENTRE.

The following meetings of the Institute have been held this year:

January 19th: Paper by Mr. J. Cooke on "Cash Accounts."

February 16th: Paper by Mr. G. J. Morris on "Stores Accounts."

After the meeting on January 19th the usual "smoker" was held and much enjoyed, but on February 16th a new departure was made, and a grand Bohemian Concert—to which the ladies were invited—was held at the Welbeck Hotel. The ladies turned up in sufficiently good numbers to out-number the gentlemen, and with a capital musical programme a very enjoyable evening was spent, all voting the experiment a huge success.

The President of the Centre (Mr. E. J. Eldridge) presided at all the functions.

SCOTLAND (EAST) CENTRE.

In spite of the extraordinary pressure of work which is being felt on all sides, we have been able to secure a full programme of papers for the 1913–14 Session. The details are given below:

October.—"The Ethics of Supervision," Mr. A. S. Renshaw, of E. in C.O.
November.—"Heavy Line Construction," Mr. Jno. Patrick.
December.—"The Training of Men," Mr. R. J. Lawson.
February.—"Underground Experiences," Mr. J. McIntyre.
March.—"Notes on Wireless Telegraphy," Mr. A. Scott.
April.—Subject to be selected, Mr. C. Crompton.

We must express our thanks to Mr. Renshaw for so readily consenting to read his paper to us, a paper which gave evidence of deep insight into the subject chosen. Mr. Patrick, by means of a number of excellent lantern-slides, showed us how to get long poles into apparently impossible positions, and at the same time unconsciously testified his ability to control a large body of men under canvas. Mr. Lawson treated the subject of "The Training of Men" on original lines and so framed his paper as to evoke most useful discussion. Mr. McIntyre's paper on "Underground Experiences" was also much appreciated, and the information he has gathered will be of great service, not only to engineers, but to the clerical staff who have to examine contractors' accounts. We look forward to the papers of Mr. Scott and Mr. Crompton, the recollection of whose previous efforts on behalf of the Institution is well remembered. It has been a real pleasure to us to have been honoured at the meetings by the presence of three former Superintending Engineers, Messrs. Eden, Campbell, and McHugh, who are all resident in "Auld Reekie."

WHIST DRIVE AND DANCE.—A most successful whist drive and dance was held on February 6th at the Carlton Hotel. Mr. and Mrs. J. D. Taylor received the guests to the number of about 100, and it was exceedingly pleasant to the host (and probably a record) to welcome no fewer than three of his predecessors in office, viz. Messrs. Eden, Campbell, and McHugh. For the sake of the young and irresponsible, the whist was not unduly prolonged, and dancing commenced at 9.30. Some of the Sassenachs found the dancing more vigorous than that to which they had been accustomed, but they were not dismayed. The closing hour came all too soon, leaving everyone with a desire for an early repetition.

Will the Editor please start a rumour that a summer picnic should take place?

SCOTLAND (WEST) CENTRE.

The second meeting of the Session was held on February 9th, when a paper was read by Mr. A. S. Angwin on "Power Supply at Telephone Exchanges."

The lecturer dealt very fully and clearly with the different methods of transforming public supplies to the required voltage, and the conversion from alternating to direct current. Short explanations were given of the principles and use of rotary converters, motor generators, mercury arc rectifiers and Nodon valves. The provision of "stand-by" plant was fully discussed, mention being made of "Boosters," which were considered to be not altogether satisfactory. For lamp-signalling exchanges it was recommended that where a public supply is available, one generator set and duplicate batteries should be provided, and it was mentioned that at Paisley Automatic Exchange it is proposed to duplicate both batteries and machines.

The third paper of the Session was read by Mr. T. Hetherington on February 23rd.

The paper reviewed the growth of the trunk system during the past ten years and the resulting congestion of the main trunk routes, which called for an alternative for open wires to provide for further development in the Service. This development was to be met by providing underground routes, on which the efficiency of the circuits would be augmented by loading. A diagram of the new cables about to be laid to towns within twenty-five miles of Glasgow was given to show the proposals for the district. The principles on which loading is based were next dealt with, and in illustration of the results obtained the case of a Glasgow–Paisley cable was worked out in detail. Finally, the financial side of the question was touched on, local cases being taken to show the approximate relation in cost between open wires and loaded underground circuits.

On February 14th the annual staff dinner of the Engineering Department in the Scotland West District was held in Glasgow. Mr. Weaver (in the unavoidable absence of the Superintending Engineer) presided over a large gathering.

The guests included the Postmaster of Glasgow, the Town Clerk and other prominent officials of the Glasgow Corporation, the Secretary of the Stock Exchange, and colleagues from the Scotland East District.

Mr. Hardie proposed the toast of the guests, and Mr. Lindsay (the Town Clerk), in replying, drew special attention to the cordial relations which existed between the public bodies in the West of Scotland and the Engineering Department.

An excellent programme of music was arranged by Mr. W. G. Robertson, who was supported by Messrs. Hunter, Loudon Hilton, Hewson, Forbes, Kirkpatrick, and Heggie. Mr. F. J. Shadforth presided at the piano for the evening.

POST OFFICE ENGINEERING DEPARTMENT: ANNUAL DINNER.

THE Tenth Annual Dinner of the Engineering Department of the Post Office was held on Tuesday, February 10th, at the Criterion Restaurant, a numerous company being present.

Mr. Slingo, the Engineer-in-Chief, presided, and among the guests present were The Rt. Hon. Herbert Samuel, M.P. (Postmaster-General), Sir Henry Norman, M.P., Mr. R. Elliott Cooper, Dr. Glazebrook, Mr. Duddell, Rear-Admiral Charlton, R.N., Professor Fleming, Mr. F. Gill, Mr. Hugo Hirst, Mr. A. M. Ogilvie, Sir John Gavey, Mr. W. M. Mordey, and Mr. A. B. Walkley.

In proposing the toast of "The Engineering Department," Mr. SAMUEL said:

I have much pleasure in rising to propose the health of the Staff of the Engineering Department coupled with the name of the Engineer-in-Chief. Mr. Slingo and his Staff have all passed through a period of alarums and excursions during the last few years. The Engineering Department is now enjoying an opportunity of settling down.

The efforts are mainly connected, at the present time, with the development of the telephone system, and that development is a steady development, but if steady it is also very certain from certain points of view. We are yet far from the state of telephone development, so far as numbers of subscribers are concerned, that we should reach in this country in comparison with other countries of the world. That our development at the present time should be slow is inevitable, and is perhaps temporary. You are engaged in the task of straightening things out—we have just absorbed the vast system of the National Telephone Company; we have had to amalgamate the organisations of the two systems one with the other. In London in the last year alone we have had to transfer no fewer than 10,000 subscribers to the Exchanges to which they should rightly belong from the Exchanges to which they have wrongly belonged, and also all over the country there has been the necessity for great extensions of the plant. It has been impossible to have simultaneously, both a happy re-organisation of our telephone system and a rapid growth if we are not to outgrow our strength, and perhaps it has been not an unfortunate thing that the adoption of the new tariff rates has inevitably been somewhat postponed. That new tariff is now completed. When it is published, and when it is adopted, it will, I am quite confident, bring to the telephone system of this country the accession of a very large number of additional subscribers, and it is well that the Engineering Department should have an opportunity of digesting what we already have, before seeking outside for a vast increase in the number of members of the public we are called upon to serve. But already this hour-to-hour development has assumed large proportions, not, as I may say, so much in the numbers of subscribers as in the preparations which are being made to deal with a greatly increased mass of business on the most efficient lines.

When I came to the Post Office four years ago the Department was spending two million pounds a year; next year it will be spending eight million pounds, and this last year it has spent nearly six million pounds, which is a simple numerical measure of the enormous increase in the work that has been thrown upon the Engineering Department of the Post Office. That in four years its expenditure could have grown four-fold is indeed a remarkable sign of the vastness of the task you are undertaking.

Of course, I have no doubt that there are many of you who will draw the conclusion that if the work of the Engineers has grown four-fold in four years the salaries should also have grown in the same proportion, but in the presence of a representative of the Treasury that is a conclusion which I should hesitate to draw on the premises.

I should like to congratulate those officers of the Department who have been concerned with the remarkable development which has taken place quite recently in the telephonic communication between Liverpool and Manchester, which, I think, is perhaps the most striking individual thing that has been done since the transfer of the National Telephone Company. To eliminate trouble and to place towns like Liverpool and Manchester on the same footing as adjoining exchanges in the same town has been no small achievement, and the change has apparently worked with absolute smoothness and to the complete satisfaction of the commercial communities of those two great cities, and the Engineering Staff is entitled to high credit for the initiation and the successful accomplishment of this reform.

Equally satisfactory is the transfer, not very long ago, of 5000 subscribers simultaneously—almost in a moment—from the old Victoria Exchange in London to the new Victoria Exchange, a transfer which also appears to have been accomplished practically without a hitch, and which, again, is very creditable to the officers who are concerned.

Then, quite recently, you have the new cable between England and Ireland on the system of loaded cables, in which the British Post Office has been the pioneer, and perhaps it is as well that the conversations between this country and Dublin should not take place —as hitherto—by way of Ulster.

I have not been quite sure that the use of machine telegraphy has been developed as fully in our Service as it might have been. I was rather inclined to suspect that the layman is chary of expressing his opinions on these matters. Possibly more could have been done in the use of machine telegraphy in various directions. As you are aware, a strong Departmental Committee has now been appointed in which we have the advantage of the assistance, once more, of Sir John Gavey to investigate and suggest any improvements that may be possible.

We are also, as no doubt you are fully informed, rapidly developing the use of automatic exchanges for telephone purposes in this country, about which I think I had the pleasure of speaking to you a year ago when I attended a similar function. In nine of the large towns of England automatic telephones are now being installed. If they are successful there, there is no doubt but that automatic telephony will have wide extension in many of our other cities.

Then, again, the Imperial Wireless Chain, about which there has been so much controversy, has at last been set going, and the actual work has now begun with the digging of the holes in the ground with a view to the establishment of the first stations. And not least interesting is the fact that since I last addressed you Parliament has sanctioned the construction of a tube railway in London for the sole use of the Post Office, the plans for which are now completed, and tenders for the work of construction will very shortly be invited.

You, with your Department, not being content with conquering the land, and the æther, and the sea, are now burrowing—efforts more than it has been accustomed to do—in the ground, so that none of this terrestrial globe shall be excluded from your sphere.

In these three matters—automatic telephony, long range wireless telegraphy, and the construction of underground railways for the sole use of the Post Office—our British Post office is once again, as it has so often been in the past, giving a lead to the whole world. In all these respects Britain will be far in advance of any other country.

Well, Gentlemen, this is the third occasion on which I have had the pleasure of attending a dinner of the Post Office Engineering Staff, and it is now four years since I had the honour of becoming Postmaster-General, and I feel quite aged as a Postmaster-General, for I think I have gone far beyond the allotted span of life for those who hold that office. Those four years have been a period of stress and of change, sometimes of difficulty, but the Department has withstood the stress and successfully accomplished the necessary changes and overcome all its difficulties, and I think we are now rapidly sailing into smooth waters. These successes have been accomplished owing to the manner in which the staff, as a whole, and perhaps especially the Engineering Staff, have risen to the occasion and have grappled with the difficulties with which they may have been confronted, and that they have so successfully achieved this is due in no small degree to the energy and efficiency of your Engineer-in-Chief, Mr. Slingo. (Applause.) He has, I know, the loyalty of his staff, the confidence of his chiefs, and I, personally, am most grateful for all that he has done to promote the well-being, efficiency and progress of this great Department of the State, and I ask you to drink the health of the Engineering Department, coupled with the name of the Engineer-in-Chief.

Mr. Slingo, in replying, said: I can assure you that it is with the greatest sincerity that we wish to express our thanks to the Postmaster-General for his remarks, and our

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appreciation of the way in which the toast has been received. The Engineering Department is one which lives in hopes of having even higher praise showered upon it in the future than we have heard to-night, but it will have to be something very big indeed in order to justify more than Mr. Samuel has been pleased to say concerning us.

You may remember that when I had the privilege of occupying this chair a year ago I viewed the coming year with a little misgiving because of the anticipated very large growth in our expenditure. It was going up, not by leaps and bounds simply, but by a species of kangaroo leaps, squared and cubed. The expenditure which we had to face was a matter of 5¾ millions, and I had a little hesitation as to whether we should be able to get through so much work as that amount of money represents. There was one thing I felt certain was necessary, and that was the loyalty and full co-operation of the whole of the staff right away down to the humblest youth or boy, and I am happy to say that I have had that co-operation, and I have had that support, and we are going to spend by the end of the financial year at least as much as we undertook to do. Now, I think if we can go through such an ordeal as that we have in a very great measure justified our existence, and are entitled to hold a gathering such as we are pleased to have here to-night.

More than that, although we have grown from a matter of two millions expenditure in 1910 to a matter of six millions this year, I have not the slightest fear whatever or the slightest hesitation in approaching an expenditure of eight millions next year, and if the Postmaster-General wants a further extension than that, I think we can be prepared to meet him. In saying that, I cannot give a more solid testimony to the thorough confidence which I have in the whole of the staff.

Now one or two things have happened during the year. We have had the Holt revision. I know it is more particularly applicable to the minor grades, but I would just make this remark—I am quite confident that the scheme propounded and as slightly modified since, is to the advantage of the men, and I am sure of this—that the longer the men study the scheme the more satisfied they will be with it, and those officers who come in contact with the men will be doing the Service a great good by letting them clearly understand that the object of the Postmaster-General and the Department in making these changes is not to penalise the men in any shape or form, but to improve their lot and to increase the efficiency of the Engineering Department.

We have been very largely engaged in straightening out. Well, it was a case of straightening out the two sets of plant or being straightened out ourselves by someone else, and I think we took hold of the stick at the right end by making up our minds that the first thing which was necessary was to weld together the two sets of plant and straighten out unnecessary feeling, and generally to bring the Service into a state of solidarity, uniformity and serviceability. With that operation we are still at work, but we do hope in the very near future we shall see that the Service has been satisfactorily reorganised. I am not speaking now of complaints on the part of subscribers—a lot of these are quite uncalled for, and those which are called for do not affect the Engineering Department. (Laughter.) I have no fear of contradiction in making that statement on this occasion.

I have to thank the Postmaster-General very heartily and you for the very kind way in which this toast has been proposed and received.

The toast of "The Visitors" was proposed by Mr. A. J. Stubbs, Assistant Engineer-in-Chief, who said:

Just as "good wine needs no bush"—whatever that may mean!—a good toast needs no butter. (Applause.) I feel sure that you, gentlemen, for whom I speak, and you, gentlemen, to whom I speak, will be very well content that this toast shall be short and crisp—with little butter.

We have amongst us to-night guests whom we welcome with our whole hearts, as great men and as friends. It does not need that the Postmaster-General be told that we are greatly honoured and greatly delighted to have him with us to-night, that we have listened to his words of congratulation with the greatest possible pleasure and delight; and he knows as well as you do that our whole function depends upon him, for the date upon which it is held is fixed at his dictation.

Amongst those whom we ought to have had as our guests to-night are many to whom our thoughts have turned—perhaps most readily the name of Sir Alexander King comes into your mind; and we are extremely sorry that he and his brother—the Lord of Post Office Finance!—are alike prevented from being with us owing to their not being very well. I dare not suggest, as I look around, that their absence has made you look sad, but I am sure that our regretful thoughts have many times this evening turned to their absence and the absence of others of our invited guests. But we have other great ones and welcome ones amongst us to-night in all directions. We have the "Lord of the Telephones"—Mr. Ogilvie. (Applause.) His name is rapidly becoming a household word throughout the length and breadth of our land. We have many high Post Office servants—great men with us (I am tempted to call them "the great underpaid"); while there are other of our guests of whom we think as by no means "underpaid"—they are rather "lords of commerce" who find it as easy to buy a motor car as we poor Post Office engineers find it difficult to buy a pair of gloves! Then there are men, the highest in our profession, the presidents of the great engineering societies, the principals of great educational institutions, the heads of consulting engineering firms, and many others.

I have been trying to avoid the mention of specific names, but I must mention one or two, because I hardly know in what connection to class them—the great engineers who have been amongst us in the times past, like Sir John Gavey, and who also, in a sense, are amongst us still, like not only Sir John Gavey, but Mr. Gill. (Applause.)

Well, gentlemen, we have not delighted in the company of these friends and great ones because they are great men, but because they are great friends: we are glad to have them in our midst to-night because we recognise that whatever their position in life has been and is, they are our friends; and we want to assure them that we are glad to have them honour our board, humble though it may be.

I will not stand longer between you and those who will respond to this toast. It is my duty to couple with this toast of "Our Guests" the names of Mr. Duddell, the President of the Institution of Electrical Engineers, and Mr. Walkley, who represents Art and Literature, if I may say so, as well as the Post Office, because his name is of world-wide renown. Gentlemen, I give you the toast of "Our Visitors."

The toast was responded to by Mr. A. B. Walkley, Mr. W. Duddell, and Sir Henry Norman, M.P.

Mr. Walkley: I am very glad to find that you have divided the honours of replying between two of us, Mr. Duddell and myself, because Mr. Duddell will be able to represent an expert's views, while I am here in the entirely negative character of a layman. I think, if you will allow me to say so, you do well, you engineers, to feast us from time to time—and no doubt the more often the better—because you engineers, if I may put it without offence, in a sense are modern mystery men and miracle-mongers, and that is a character I view like the rest of the world with certain misgivings. The remark applies with peculiar force, I think, to engineers who deal with the strange, still unexhausted force of electricity. One of the strangest things about it is that it has always surprises in store. You are always pursuing the elusive nymph of electricity and she is always fleeing, and just as you think she has escaped you she proves, like other nymphs, unexpectedly prodigal of her favours. And after that you go about "fey" men, a little uncanny. In mediæval times they would have crystallised this in the statement that the Devil was the first engineer. After all, in the progress of the ages the Devil has been credited with so rich and varied an initiative that I think he can very well afford to spare that particular attribute. But that is why I suggest that you do well to entertain us and to let us see that you are not merely engineers—those strange, uncanny beings—but that you are also men and brethren. I think, as I speak, of the song that is now something of a nuisance all round London—"You made me love you: I didn't want to do it." I will not say we didn't want to love you engineers—we have always wanted to love you—but there has been that little difficulty about the mystery of you, and you do well to make us love you by your very charming hospitality.

Gentlemen, on behalf of the lay guests, I return you my very best thanks.

Mr. Duddell: It gives me the greatest pleasure to get up and thank you for the very cordial way in which this toast has been proposed, and the way in which you have honoured it. The last speaker seems to have been guilty of responding on the "expert" side. I may tell you that I must plead guilty of being very largely a guest. I think I am thoroughly expert at being a guest. On the subject of guests and how they shall be treated I can tender my services—a very simple thing! Since 1904, when I first had the pleasure of going to the Post Office and meeting Sir John Gavey, I have always felt somehow or other that I was one of you. So many of you I know by sight, and large numbers of you I know so well, that I feel when I am among you that I am among friends. The pleasure I feel at being your guest to-night is enhanced because of what we have heard on the subject of the money that is going to be expended on the telephones next year. During the last few months there have been startling changes appearing, and the extra few millions, and I may have perhaps still more experience of the telephone system. To-night we have heard of 5000 subscribers being transferred at one "go." This transfer is a big one. I was transferred, but after the change people did not know I had been transferred! As a result I was constantly asked, "Are you number so-and-so?" The exchange did not seem to act upon my transfer. Yes, it is a strange thing to effect such success as my transfer.

Well now, gentlemen, I wish to say on behalf of the Institution of Electrical Engineers that you are still the first branch of electrical engineering, and still the most important from many points of view. We are always glad to have you, and hope to have you in our building and to give you every entertainment we can.

On behalf of the guests and on my own behalf in particular I beg to thank you for the very cordial way in which you have drunk this toast.

The CHAIRMAN then said: Mr. Walkley has replied for the laymen! Mr. Duddell has replied for the expert guest! Now, I think, we are really entitled to, and should much appreciate, a little response on behalf of the unofficial guests, and Sir Henry Norman has therefore very kindly consented to respond to the toast.

Sir HENRY NORMAN: I have often, very often, had occasion to feel a sense of my own shortcomings, but I never felt so keen a sympathy with an actual criminal as I do at this moment, because, as you all know, when a French criminal is first sentenced to the guillotine the date of his execution is mercifully withheld from him until the moment arrives, and at that moment the governor of the prison says, "Courage, my friend, the moment has come." Your Chairman has paid me that compliment to-night, because, when I had enjoyed a most excellent dinner, he suddenly said at the last moment, "Courage, my friend, the moment has come for you to make a speech." I am very much honoured to be associated with your other guests, with my old friend Mr. Walkley, whom I have known for more years than I care to remember in his many capacities and multifarious tasks, so that I was not surprised when I read in the papers that he had blossomed forth as an authority on high-speed telegraphy.

Mr. Duddell is among the most eminent of our electrical experts in this country, and he is, rightly so, often chosen to represent us in scientific circles abroad. I gathered from what fell from the Postmaster-General or the Chairman—I forget which—that you gentlemen are responsible for the London Telephone Exchanges. If that is so there may be somebody here present who is responsible for the Regent Exchange. I do not see anyone standing up. (Laughter.) Well, all I want to say is this: that at the Regent Exchange there is a lady. I have not the pleasure of her acquaintance, apart from a familiarity with her voice over the telephone, but if the gentleman who is responsible for the Regent Exchange is here present and is able to convey this suggestion to the lady at the Regent Exchange, can he persuade her not to ask me to drop a penny in the box at my private house when I wish to communicate with another subscriber? (Laughter.)

I will tell you another personal experience.

I was recently in company with an eminent gentleman who with myself was called upon to be present at an official committee, but unfortunately the secretary of that committee had given us a wrong address, and none of our fellow committee-men were there. We were alone, and we knew that the chairman and our fellow-members were awaiting us, and we felt very embarrassed, as we did not know where the committee was meeting.

We thought that we would telephone to some Government headquarters, just to ask where the committee was meeting that day. So we telephoned—I should say we tried to telephone. There were difficulties, and there were some difficulties, and there were many difficulties. I do not propose to tell you them all. At any rate, at last we got through on the telephone, and the gentleman who was with me turned round and said, "You will notice, Sir Henry, that the telephone difficulties in London are all administrative and not engineering." I am not surprised that I heard your Chairman to-night express a similar sentiment. It appears to me to-night that the talents which have been successfully displayed in the administration of the technical and engineering side of the telephone system can be brought to apply to some of the problems of the House of Commons, which might perhaps be to our advantage there. I wanted a seat in the House of Commons to-day in order to hear the speeches on both sides on this historic occasion. In order to get a seat it was necessary for me to be outside the door of the House of Commons this morning at 6.50, and to wait hours before I could go in to claim my seat. I think that you who have so much to do with automatic selection of the telephone system can surely apply something like that to enable us to get our seats without going through that childish course. Of course you have an automatic selector! It will be necessary to have an automatic gas pressure regulator. You will also have to add an automatic cut-out. (Laughter.) However, I had the privilege of spending a very short time with you—far too short for my happiness as a member of the Post Office staff; and, joking aside and coming to seriousness, I can bear testimony to the fact of my own personal knowledge, that, so far as I am able to judge, the Post Office is the most efficient department of the public service. (Applause.) During the short time I was there it seemed to me that the public were always ringing the front door bell, and had to be answered immediately. I am quite certain that the Post Office has no more efficient staff than the Engineering Staff. Some of you, I am very glad indeed to learn from the Postmaster-General to-night, are connected with the foundations for the building of the first stations of the Imperial chain which are being dug. This, of course, is the beginning, and I am very glad indeed to know that this first step has been taken. I have not always been able to see eye to eye with my friend the Postmaster-General on the matter of the Imperial chain of wireless stations, but I can certainly say that it would have been impossible for the Post Office and the national interests to have been represented in the House of Commons by a man who worked with a more single eye to the public interest, or who devoted so much labour to attain what he believed to be the highest possible results.

Mr. Samuel has spoken to-night in some strange manner of the expiration of the allotted span of the Postmaster-General. I can only say that, speaking as a member of the public, with some opportunity of knowing what is going on, I certainly hope that this is not applied to his own particular case. If it is, I can only say that, in view of the very great number of men in the public service dependent upon the Post Office administration, of which he has given us in his annual statement in the House of Commons year after year such an example, I should think it is an unequalled record of achievement of the Postmaster-General and his staff, and I would add that his successor, whoever he may prove to be, will have a very difficult task to follow along the same lines. During the very brief time I passed at the Post Office, certainly among the most happy and profitable moments of my life, I felt very honoured.

Gentlemen, I thank you for the way in which you have received this toast.

Mr. Moir, in proposing the toast of "The Chairman," said: I have much pleasure in rising to propose the toast of the Chairman, and, lest you should have any misgiving as to the length of time which I am likely to occupy in submitting this important toast for your acceptance, I should like to explain at once that, in official parlance, I have been discreetly reminded that he who undertakes work on behalf of the Engineer-in-Chief does so with a time-limit and a penalty clause attached to his contract. I am glad on your account to have been given this gentle hint, otherwise I might have been tempted to pour upon your innocent heads a perfect deluge of words. For example, Mr. Slingo is the sixth Engineer-in-Chief under whom I have served, and I still survive! In a spirit of gratitude, therefore, I should have been tempted to have spent half an hour or so upon "The Lives of the Engineers-in-Chief," after the manner in which Johnson dealt with the Lives of the Poets, but the penalty clause forbids

Again, some of you in this room have known Mr. Slingo from his youth upwards, so to speak; I have not been so fortunate. I have known him only as Staff Engineer, Superintending Engineer, Assistant Engineer-in-Chief, and in his present position. But, Gentlemen, these are four of the great ages of man in the Engineering Service of the Post Office, and, looking round this room to-night at the brave show made by our young Engineers—the future hopes of the Post Office—with the wave-lengths of their faces not unduly extended; their physical proportions not attenuated to any great extent; their mental installations well-equipped and closely tuned, so as to enable them to deal effectively with the problems in lighter engineering which become more numerous and more complex from day to day; and with their hearts well charged, I make no doubt, with clean and healthy ambition, I should have liked on their behalf to have spent a quarter of an hour or so on "The making of an Engineer-in-Chief" as personified in our Chairman himself—but the penalty clause forbids.

I come, therefore, to Mr. Slingo as we know him to-day—certainly one of the busiest men at the General Post Office. I had intended to have made reference to the manner in which he had undertaken the heavy responsibilities placed upon him since he became Engineer-in-Chief, but after the handsome and well-deserved compliments paid to Mr. Slingo by the Postmaster-General it would be presumption for me to add anything as to his high attainments.

I should like, however, to tell a short story about a countryman of my own who entered a chemist's shop and placed an order for two-pennyworth of laudanum. The chemist, having the Poisons Act in his mind, looked his customer up and down, and said, "What do you want it for?" His customer, missing the chemist's point of view, but responding readily to the inward calls of what is popularly believed to be his ruling passion, answered: "What do I want it for? I would like it for a penny!" Well, gentlemen, the question you will now like to ask me is which is the Engineer-in-Chief, and my answer is that neither of these two represents the Engineer-in-Chief. Mr. Slingo does not want two-pennyworth of laudanum for a penny, but he wants two-pennyworth of laudanum for twopence, and he is very well qualified to know when he gets value for his money, and, therefore, you need never on any occasion endeavour to sell the Engineer-in-Chief a pennyworth of laudanum for twopence. But, although Mr. Slingo, as this story illustrates, is well qualified to look after the interests of the Department, he is also very familiar with the whole of the conditions of the staff, and has a sympathetic feeling towards any reasonable demand that may be made upon him. After all, gentlemen, what quality more than any other is required to-day by those who are placed over the large Departments of the Post Office, or who occupy, for the time being, the Chairmanship of Committees dealing with Staff matters? It is the quality and the capacity of being able to weigh evenly in the balance the sometimes conflicting claims of employers and employed.

Gentlemen, the toast is "The Engineer-in-Chief."

The CHAIRMAN replied in the following terms: Gentlemen, I am very grateful for the toast proposed. There can be no doubt of what Mr. Moir said that everyone wants two-pennyworth of "mustard" or whatever it was for twopence, and I do hope that it is realised throughout the Service, that no one wants more than two-pennyworth for twopence. But we do want to justify our existence to show that we are what we pretend to be with eyes, ears, brains and thoughts, at the bottom of the whole business. I am very much obliged indeed for the way in which the officers of the Department have responded, not only to this toast to-night, but to the very pressing and great demands which have been made upon them during the past year. I think the organisation which we have been able to set up and develop during the past year will enable us to cope with anything that is likely to occur in the future.

During the evening an excellent musical programme was contributed to by Miss Lillian Burgiss, Miss Margaret Norton, Mr. Murray Ashford, and Mr. Charles Wreford.

The preliminaries in connection with the Dinner were admirably organised by a committee representing the Engineer-in-Chief's Office and the London and South-Eastern Engineering Districts respectively.

To Messrs. R. A. Wells and L. J. Farries, the joint Honorary Secretaries, high praise is due for the carrying through of a most successful function.

THE TELEPHONE AND TELEGRAPH SOCIETY OF LONDON.

THE fourth meeting of the current Session took place on January 26th, when Mr. G. F. Mansbridge of the Stores Department, gave an excellent paper on the subject of the "Manufacture and Repair of Telegraph and Telephone Apparatus at the Post Office Factories." Although the paper was longer than usual, interest did not flag in the least. Indeed, most of the audience were disappointed only because the available time did not permit of more than the lifting of the veil which covers the mysteries of the factories. The subject was in fact so wide that one moment we were in spirit at the timber-felling camps in Australia, and the next at a remote local store watching the packing of returnable stores in a thoroughly unique and unorthodox manner.

Mr. Mansbridge, after dealing with the history of the factories and the probable future arrangements, explained in detail the methods of manufacturing wooden arms for telegraph poles from eucalyptus wood, and the need for careful scrutiny of the wood before and during the process of manufacture so as to discover flaws, especially those caused by side-slips across the grain at the time of felling the timber. He described the method of automatically collecting dust and chips as they were produced and conveying them to the furnace.

Apparently they make and repair casks at the factories by sleight of hand, but, although the process was fully described and illustrated on the screen, their subsequent uses were left to the imagination. The description was sandwiched between "arms" and "waste material," but I am informed on high authority that the context was accidental.

Scrap material at the factories seems to be a misnomer, as apparently they never scrap anything, using the material over and over again in different forms. All of us were very proud to hear of the clever methods for separating copper from gutta-percha, of the Lucas battery and the Mansbridge condensers.

Mr. Mansbridge described the method of dismantling, repairing and reassembling instruments and switchboards, and all the system for turning old plant into new, the process of lacquering by aërograph instead of by brush, the devices for constructing Wheatstone chain and the use of automatic and semi-automatic tools. He also described the new factory which is being built at Birmingham, and the arrangements which will be made there to utilise electric power to an unusual extent.

When, later, Mr. Mansbridge discussed the question of piecework *versus* daywork, he expressed himself as strongly in favour of the former. I cannot do better than give the following extracts from his paper, viz.:

"Scamping is encouraged, not by piecework as such, but by slack supervision and inefficient examination. Workmen, being human beings, differ in their characters, but the average workman, if he gets a decent piece-price, takes a genuine pride in turning out a good article, and this pride is none the less if he knows that rejection would certainly be the fate of poor work. Piecework properly managed is an advantage to the workman and an advantage to the employer. It results in increased output, it enlarges the sum over which the overhead charges have to be spread, and thus, by reducing the percentage of establishment charges, enables a reduction in total cost to be effected. Moreover, it is an excellent medium for training young hands and for separating at an early stage those who are suitable for mechanical work from those who are not. The workman who can turn out first-class work, but who requires twice the normal time in which to do it, is not an efficient workman, and the sooner he is brought to realise this the better, and there is nothing like piecework for putting this to the test. In London what is known as plain piecework is in force. Under this system the aim is to fix piecework price at such a figure that a workman of average skill should be able to do a job in about four fifths of the time represented by the piecework price—that is to say, five hours would normally be reckoned as the right time to allow for a job which a man working at piecework speed would accomplish without undue effort in four hours. On this basis he would receive five hours' pay for four hours' work, or, as he would put it, he would earn 25 per cent. profit. If he did the job in less than four hours, the pay would, of course, be the same, but his profit would be greater. If he took longer than four hours, his profit would be less, and if he took more than five hours he would make a loss which might or might not be made good to him, according to the system in force, although the tendency in the best outside factories of late years has been towards making up such losses where they are not the result of laziness or deliberate misconduct on the part of the workman. As a general rule, the profit week in and week out all round the factory ranges from 20 to 25 per cent., but, as with most other things, jobs differ and men differ."

Mr. Mansbridge announced that, for the sake of uniformity, the Nottingham and Birmingham factories would soon be brought under the "plain piecework" system now in force in London.

The fifth meeting took place on February 23rd, when Mr. B. M. Wylie (A.G.D.) read a paper on "Telegraph and Telephone Accounting," which was, I believe, the first serious attempt to give a general survey of the system of accounting for those services. Mr. Wylie, indeed, showed us the "whys" and the "wherefores" of some of those irritating financial details which, as Mr. Waldegrave (A.G.D.) pointed out later, we do not suffer gladly even in private life.

Mr. Wylie, with all his enthusiasm for his subject, complained of difficulty in kindling the spark of life in its dry bones. If the writer of these short notes fails miserably to preserve that spark, the reader must ascribe the failure either to the fitfulness of the original spark or the clumsy use of the bellows.

Mr. Wylie dealt at some length with the financial history of the Telegraph and Telephone Services, and then described the method of Parliamentary control, which, starting with the Treasury Officer of Account (the Comptroller and Accountant-General), and continuing through the Treasury, the Comptroller and Auditor-General and the Committee of Public Accounts to the House of Commons itself, makes it so difficult for a Government Department to conduct its affairs on ordinary commercial lines. Much of the work of the Accountant-General's Department may be said to be directed towards securing the observance of the regulations governing Parliamentary accounting, and towards codifying receipts and expenditure in such a way as to enable accounts to be prepared in a form acceptable to Parliament.

All expenditure on the Telephone and Telegraph Service is provided for either by loan or moneys voted by Parliament. The money so obtained is specially allocated to specific purposes, and the misapplication of the money is a heinous offence. Hence the difficulty at times of obtaining promptly those small articles which are purchasable from the funds of another Department, and which in the commercial world would be bought off-hand from "petty cash."

It is this fear of misapplication (or misappropriation, as Mr. Wylie perhaps more properly but less prettily calls it) which makes it so necessary for the Accountant-General to pay such particular attention to the spending sides of our great organisation. So far as services common to the telegraph and telephone services are concerned, the apportionment is now carried out in the Accountant-General's Department with much accuracy and much less friction.

The annual receipts from the services are paid into the exchequer as revenue after passing through various conduits from the point of collection to the Accountant-General. We are all aware of the method of prepaying telegrams by means of postage stamps; and it appears that the average value of an inland telegram is calculated periodically and multiplied by the total number of telegrams, and the amount so arrived at is deducted from the money received from sales of stamps. In the case of the telephone service, the greater value of the actual fees, etc., paid by postage stamps is calculated.

But apart from the payments by postage stamps, there are some millions of telephone revenue which are collected by District Managers. This revenue is divided into two parts, viz. Exchange and Trunk. Generally speaking, the basis of the Exchange service is the subscriber's agreement, which provides for the payment of rental, etc., at a published tariff. Acceptance of the agreement is followed by the issue of an advice note which is the primary accounting voucher. This advice note is issued to the Superintending Engineer and contains full particulars of the service required. It is returned to the District Office when the engineering work is completed, an entry then being made in the rental register and an account rendered to the subscriber. Any engineering work performed for a subscriber, even though not involving a new agreement, is made the subject of a separate advice note. Local fees are dealt with by means of valued sheets, *i.e.* a printed sheet, one for each subscriber, provided with columns showing consecutive numbers of calls, the corresponding values, and spaces for indicating periodically the number of actual calls made by the subscriber. Without this valuable record it would be practically impossible to secure the prepayment of the charges for local calls. Trunk fees are posted direct to the subscribers' accounts from the trunk tickets.

The District Managers pay all moneys directly received by them, or transmitted to them by Postmasters, into appointed banks, whose acknowledgments called accountable receipts are transmitted to the Accountant-General. They cannot draw cheques on these banks, all payments for wages, etc., at district offices being made through the postmasters. With the limited space at my disposal, I cannot follow Mr. Wylie through the questions of commercial accounts, etc., but I can safely recommend the paper as worth careful study by those concerned.

The sixth paper of the Session was read by Mr. James J. Tyrrell, of the Cable Room, Central Telegraph Office, on March 23rd, and its title was "Some Difficulties of International Telegraphy." Not having had any practical or theoretical experience of the telegraph service, I will apologise at once for any misconceptions of Mr. Tyrrell's paper which I may in ignorance put forward.

Mr. Tyrrell explained fully the methods of working the telegraph channels to the continent. He is strongly of opinion that whatever may be the merits of the "operator output" as a unit of comparison in the case of inland telegraph lines, the special conditions of the international service render such a unit totally inapplicable to the latter. His arguments on this point were cogent; and he urged that, having regard to the capital value of the plant, the proper business proposition was a "circuit output" unit. He pointed this moral by comparing the cost of a little additional staff with the extra revenue which might be earned by the expensive plant. Members of the sister service will appreciate this view when they remember what excellent results attended the provision of ample staff for the long-distance inland telephone trunk wires.

But, as Mr. Tyrrell pointed out, the full advantage of additional staff at the Central Telegraph Office would not be obtained unless the Foreign Administrations concerned were prepared to staff their ends of the channels as generously as this administration. Apparently he is not sanguine of their willingness to do so, and he quoted cases where the foreign ends are at present less adequately staffed than the British ends. In connection with the staff question he pointed out that generally speaking the international wires work less efficiently in the early hours of the day than they do later on, and that consequently there is a certain accumulation of traffic towards the periods when the staff at the Central Telegraph Office is being automatically reduced.

Some interesting reasons were given for the difficulties of working the international service, one being that each nation assumes that its methods of construction and maintenance are superior to all others, and is difficult to convince that a fault in its own territory is not due to a hundred and one other possible causes within the remedy of its neighbour. The national representatives will not first remove the beam from their own eyes before examination of the specks elsewhere. Unfortunately nations are not singular in this respect. Mr. Tyrrell urged that every possible means should be used to convince the foreigner that the interruption of communication is not due to faults in British maintenance, and with this object he considered that repeater stations should invariably be placed as near as possible to the cable ends. Still, even then, if one may judge from the tenour of his paper, he fears the blindness of those that will not see.

Arrangements are being made to print all the papers which have been read before the Telephone and Telegraph Society of London during this Session, and a copy of each paper will be supplied gratuitously to each member of the Society. I hope that each member will derive much benefit from the perusal of the papers, as many points must of necessity be overlooked when one is merely listening to an address for the first time or scanning a hopelessly inadequate summary of it. J. W. W.

BOOK REVIEWS.

'Practical Uses of the Wave-meter in Wireless Telegraphy,' by J. O. Mauborgue, First Lieutenant 24th U. S. Infantry: formerly Instructor Army Signal School, Fort Leavenworth, Kansas. (Published by the Hill Publishing Co., Ltd., 6, Bouverie Street, London, E.C. Price 4*s*. 2*d*. net.)

This work, which in its manuscript form passed through the critical hands o Prof. G. W. Pierce, was written originally by Lieut. Mauborgue for private reference in the Army Signal School at Leavenworth, Kansas. It has now, by order of the Secretary for War, been officially adopted.

No unnecessary preliminaries are indulged in by the author, who goes straight to his subject by a definition of what constitutes a wave-meter passing on to log: decrements, oscillation constant, damping, syntony, etc. Chapters II and III are devoted to various types of wave-meters in use and the manner in which they are used for wave-length determinations.

Chapter IV, which for the practical wireless engineer is perhaps the most important in the book, deals with the tuning of the sending station, and is a lucid exposition of the way in which this all-important operation should be carried out.

In the remaining chapters methods are given for measurement of damping, decrement, inductance, capacity, etc., by means of the wave-meter, and a logarithmic chart is supplied for the purpose of finding the frequency corresponding to any wave-length, the wave-length corresponding to any given capacity and inductance, etc.

Two obvious misprints occur in the book, viz. on p. 30, line 18, λ should be λ_2; and on p. 62, first equation, the ratio in the right-hand member should be multiplied by C, and not the first term in the numerator.

On the whole the book is one that can be heartily recommended to all who are interested in wireless telegraphy. It is excellently printed, and the text is interspersed with many diagrams and illustrations.

'Telephone Erection and Maintenance: A Handbook for the Contractor and Wireman,' by Herbert G. White. (Published by Messrs. S. Rentell & Co., 36, Maiden Lane, W.C. 125 pp. and index. Price 1*s*. 6*d*. net.)

In his preface the author states that his "main object is to explain the principles underlying domestic telephones of the type that the electrical contractor and wireman have to handle," and that "no attempt is made to deal with public telephone service." The book is not, therefore, one which will appeal to Post Office employees generally.

The various types of magneto and battery-ringing direct-circuit installations, secret and non-secret intercommunication systems and switchboard installations in common use are clearly described and the illustrations are adequate and good. Stress is laid on the necessity for carefully planning and executing every detail of any work, and practical directions are given which will well repay observance.

The author recommends the use of two-groove insulators for transposition purposes when open wires are run for any appreciable distance adjacent to a power circuit, but in a damp climate such as ours it is better to provide two independent insulators per wire at each transposition point.

There are a few errors of spelling, etc., which, in the event of a reprint, will doubtless be eliminated.

'Automatic Telephony,' by S. Turner, Engineer-in-Chief's Office. (Published by 'Electricity.' Price 6*d*. net.)

This little pamphlet of thirty-two pages is a reprint of a short series of articles published in 'Electricity,' July 4th, 1913, etc., and outlines in very simple language the mechanical and electrical operations of the automatic circuits used in a "Strowger" Exchange for joining together two automatic subscribers in a three-figure system. For each stage of a connection, a separate circuit with the essential apparatus only is shown. The diagrams are, therefore, simple and easily followed. The manuscript deals with the connections of a local call from first principles, and should be useful as a first step to students of automatic telephony. J. H.

'Practical Electrician's Pocket-Book, 1914.' (Rentell, cloth 1*s*. net; Rexine [with Insurance]. Price 1*s*. 6*d*. net.; postage 3*d*.)

The 1914 edition of the little red book is again before us, and we are pleased to note that the editor and his assistants do their utmost to maintain the up-to-date character of this most useful work in every respect. This year chapters have been added on 'Electric Welding' by Mr. R. J. Wallis-Jones, M.I.C.E., M.I.E.E., and on 'Electric Heating and Cooking' by Mr. 'Tricity Grogan, whose work in this direction is so well known to the majority of our readers. Other important additions deal with Automatic Electric Lighting Plants, Electro-Plating, Electric Cranes and Lifts, Electric Signs and Flashers, and other interesting and practical subjects too numerous to mention, the net result being an increase in size of some fifty-eight pages. We are sure that this little handbook will meet with the reception which it so well deserves.

'Questions and Solutions in Magnetism and Electricity,' by William J. White, A.M.I.E.E. (Messrs. S. Rentell & Co.; Whittaker & Co. Price 1*s*. 6*d*. net.)

In this little book Mr. White has furnished solutions to the questions set at the examination by the Board of Education and latterly by the C. and G. of London Institute in stage 1, Magnetism and Electricity, over the period 1907–1913. Care has evidently been taken to ensure accuracy and straightforward answers, and the sketches illustrating them are well done. The book should be very useful to telegraphists in their efforts to secure the double increment, and also to the workmen now attending the first year's course drawn up by the Department and being taught at the various institutes. The value of the book is enhanced by the index given at the end, which summarises the portions of the subject dealt with in the questions.

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ENGINEERING DEPARTMENT CHESS CLUB.

A friendly match was played on December 1st, 1913, with Messrs. C. & E. Morton's Club, and won by eight games to two, but the Club has yet to record its first success in the Civil Service League.

The Club Competitions have provided some interesting contests and are now nearing completion.

It is hoped to hold the Annual Dinner during April.

DEATH OF MR. J. T. DEAN.

Members of the staff of the old Metropolitan District, as well as of the now also extinct Metropolitan (North) District, will hear with much regret of the death of Mr. James T. Dean, late Chief Clerk of the Districts named, which occurred with painful suddenness in the early hours of Sunday, November 30th, 1913.

Mr. Dean entered the service of the Department so long ago as June 20th, 1872, and was transferred from the Central Telegraph Office to the Engineer-in-Chief's Department in May, 1880. He successively passed through the grades of Junior and Senior Clerk, and ultimately received the appointment of Chief Clerk to the now extinct Metropolitan District on November 30th, 1899, on the retirement from that position of Mr. Edward Collard, who survives him. In August, 1907, Mr. Dean, much to the regret of his many friends, was compelled to retire in consequence of ill-health, and since that time he has resided at Portslade, Sussex, where he was well known and much respected.

Mr. Dean was an enthusiastic whist player, and it was while indulging in his favourite game that the fatal blow fell, which removed from the world one of the most kindly and sympathetic of men. This occurred about 10 o'clock on the evening of November 29th, and Mr. Dean was at once removed to his home, but never again regained consciousness. He expired at 12.30 on the following morning. Death was certified as having been caused by epilepsy and coma.

All who knew Mr. Dean will feel that they have lost a firm and true friend, and their regret at his loss will find expression in much sympathy for Mrs. Dean in her great bereavement.

W. H.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From.	To.	Date.
Kingston, J. R.	Asst. Engr.	Exec Engr.	28 : 11 : 13
Gwyer, J. H.	Chief Inspector	Asst. Engr.	To be fixed later.
Armstrong, E.	„	„	
Smith, F. M.	„	„	
Curling, R.	„	„	
Speight, A.	Junior Engr.	„	
Smith, N. S.	„	„	
Bastow, F.	„	„	
Hembrough, J. R.	„	„	
Ellery, A. Q.	3rd Cl. Clerk, London Dist.	2nd Cl. Clerk, London Dist.	18 : 10 : 13
Pestell, G.	3rd Cl. Clerk	2nd Cl. Clerk	19 : 12 : 13
Martin, L. C.	Junior Engr.	Asst. Engr. on probation.	3 : 1 : 14
Peck, H. G. S.	Chief Inspector		3 : 1 : 14
Kingsbury, H.	Junior Engr.		22 : 1 : 14
Nancarrow, F. E.	—		1 : 1 : 14
Faulkner, H.	—		5 : 1 : 14
Gregory, H. J.	—		9 : 2 : 14

STAFF CHANGES.

TRANSFERS.

Name.	Rank.	Transferred from	To	Date.
Beeton, H. G. . .	Asst. Engr.	E. in C.O.	Met. Power	12 : 1 : 14
Williams, R. H. . .	,,	,,	London	21 : 1 : 14
Grieveson, A. F. .	Asst. Engr. on probation	,,	S. E.	18 : 1 : 14
Boryer, W. F. . .	Ditto	,,	London	18 : 1 : 14
Campbell, H. M. .	2nd Cl. Engr.	N. Mid.	E.	9 : 3 : 14
Strong, E. . . .	Junior Engr.	E. in C.O.	Testing Branch	8 : 2 : 14
Day, T. F. . . .	Chief Inspector	Testing Branch	E. in C.O.	1 : 3 : 14
Simpson, W. W. .	3rd Cl. Clerk	Sc. W.	S. Mid.	5 : 10 : 13
Pine, T. F. . .	,,	S. Lancs.	,,	9 : 11 : 13
Schofield, W. H. .	,,	Sc. W.	,,	2 : 11 : 13
Corney, P. A. . .	,,	N. E.	,,	28 : 9 : 13
George, T. B. . .	,,	S. Mid.	London	1 : 11 : 13

RETIREMENTS.

Name.	Former.		Particulars.	Date from which to take effect.
	Rank.	District.		
Fletcher, T. . . .	Asst. Engr.	E. in C.O.	Superannuated	25 : 1 : 14
Johnston, D. W. . .	3rd Cl. Clerk	,,	,,	13 : 2 : 14
Robertson, G. A. . .	,,	Scot. East	,,	18 : 3 : 14

DEATHS.

Name.	Rank.	District.	Date.
Cleary, W.	Asst. Engr.	South Lancs.	20 : 1 : 14
Rydings, J. M. . . .	3rd Cl. Clerk	,,	4 : 1 : 14

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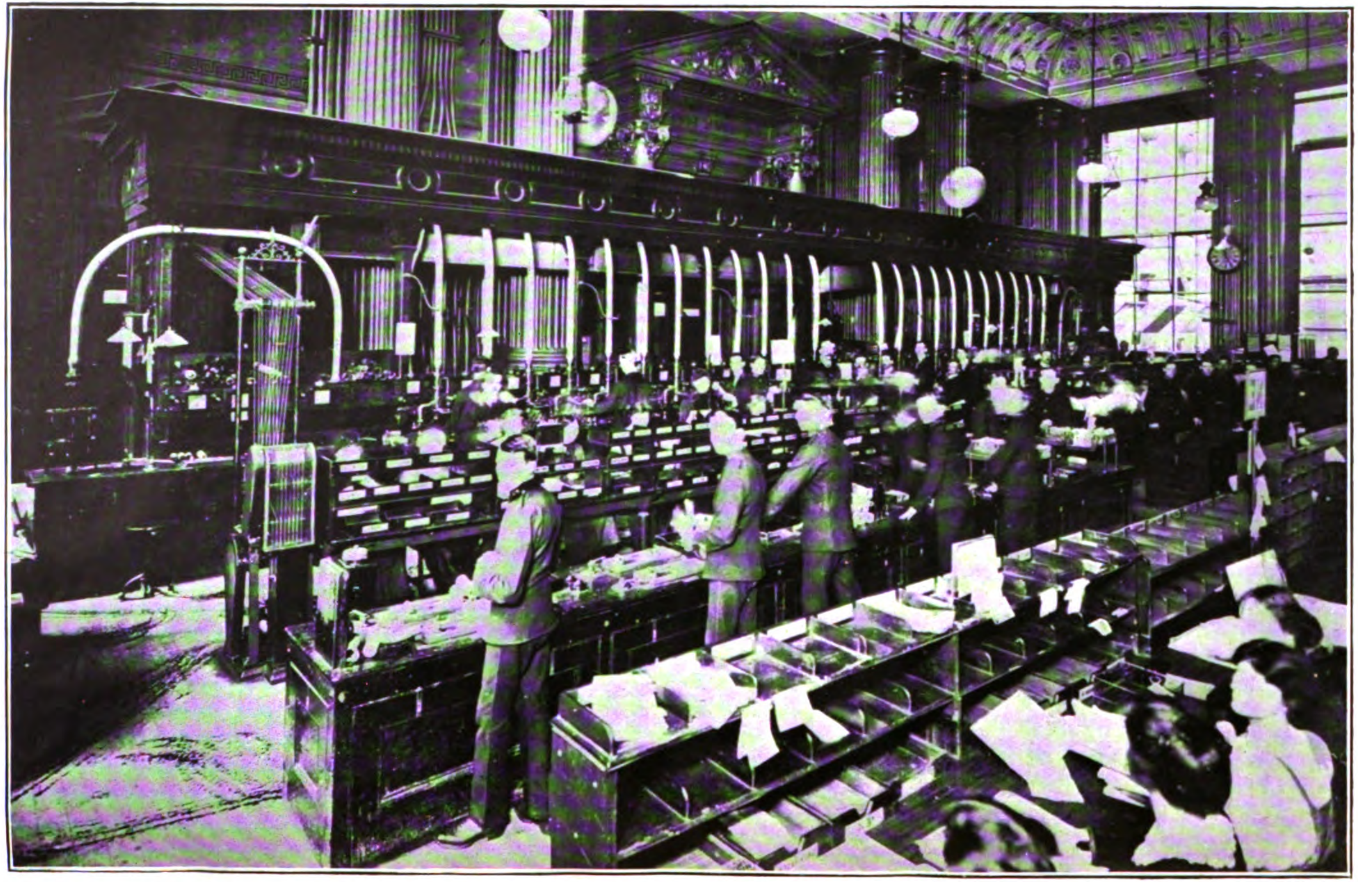
All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.

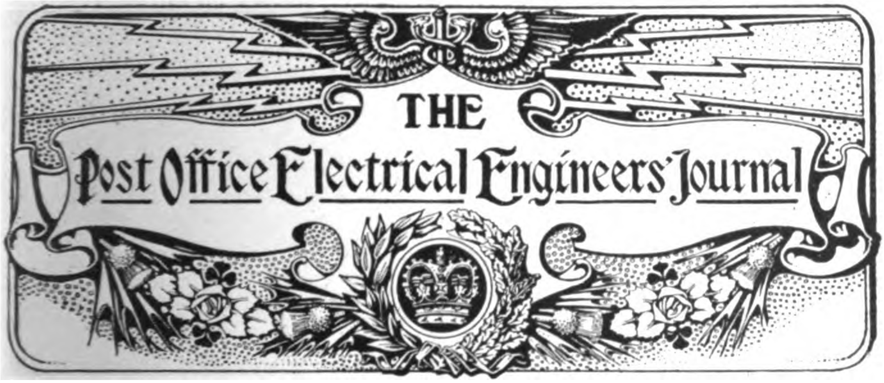
A few copies of each of the following numbers of the JOURNAL are required by the Board: Part 1, Vol. 1; Part 2, Vol. 3; Part 1, Vol. 5, and Part 2, Vol. 5. Full price will be paid for copies in good condition, or other numbers can be sent in exchange. The journals may be sent to the Managing Editor direct, or through the local agents.

Binding covers and copies of the Contents Index for Vol. 6 are now available, and may be obtained from the local agents for 1*s.* and 2*d.* respectively.

Subscribers can have their copies bound, with index included, at a cost of 1*s.* 9*d.*, by sending the JOURNALS to the local agents. Orders should indicate whether the original binding covers, or the later pattern, are required.



Tube Room, Central Hall, Central Telegraph Office.



THE
Post Office Electrical Engineers' Journal

DARLINGTON AUTOMATIC EXCHANGE.

By J. Hedley,
Engineer-in-Chief's Office.

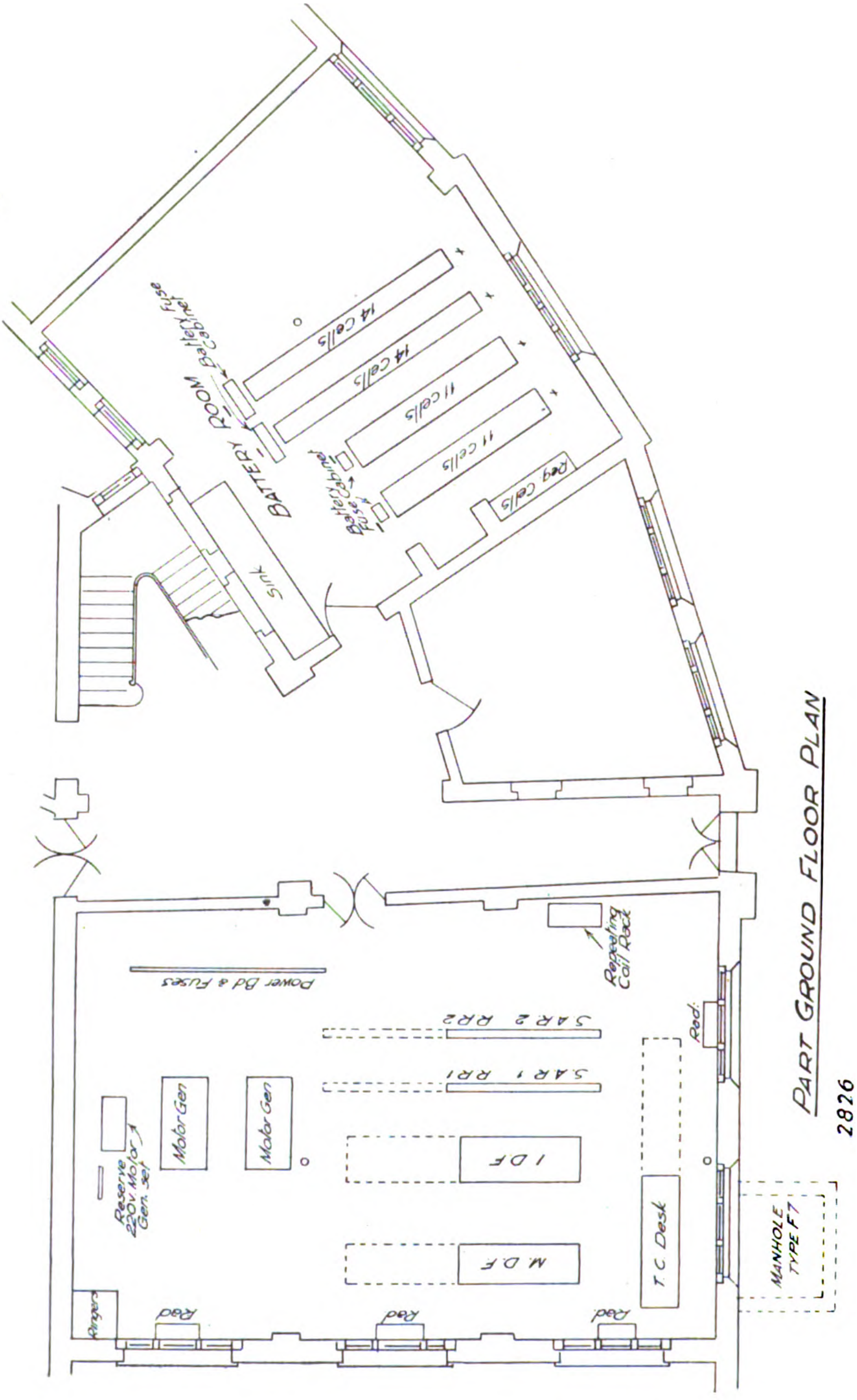
This exchange equipment has been manufactured and installed by the Western Electric Company, and will be the first full automatic exchange of that Company's system to be brought into public service. For that reason it is thought a description of the operation of the automatic circuits and the underlying features of the system will be interesting to readers of this Journal at home and abroad.

The equipment at the existing local exchange is of the magneto type, generator call and clear, with approximately 570 working subscribers. At the existing trunk exchange six Post Office trunk sections, type D, are fitted.

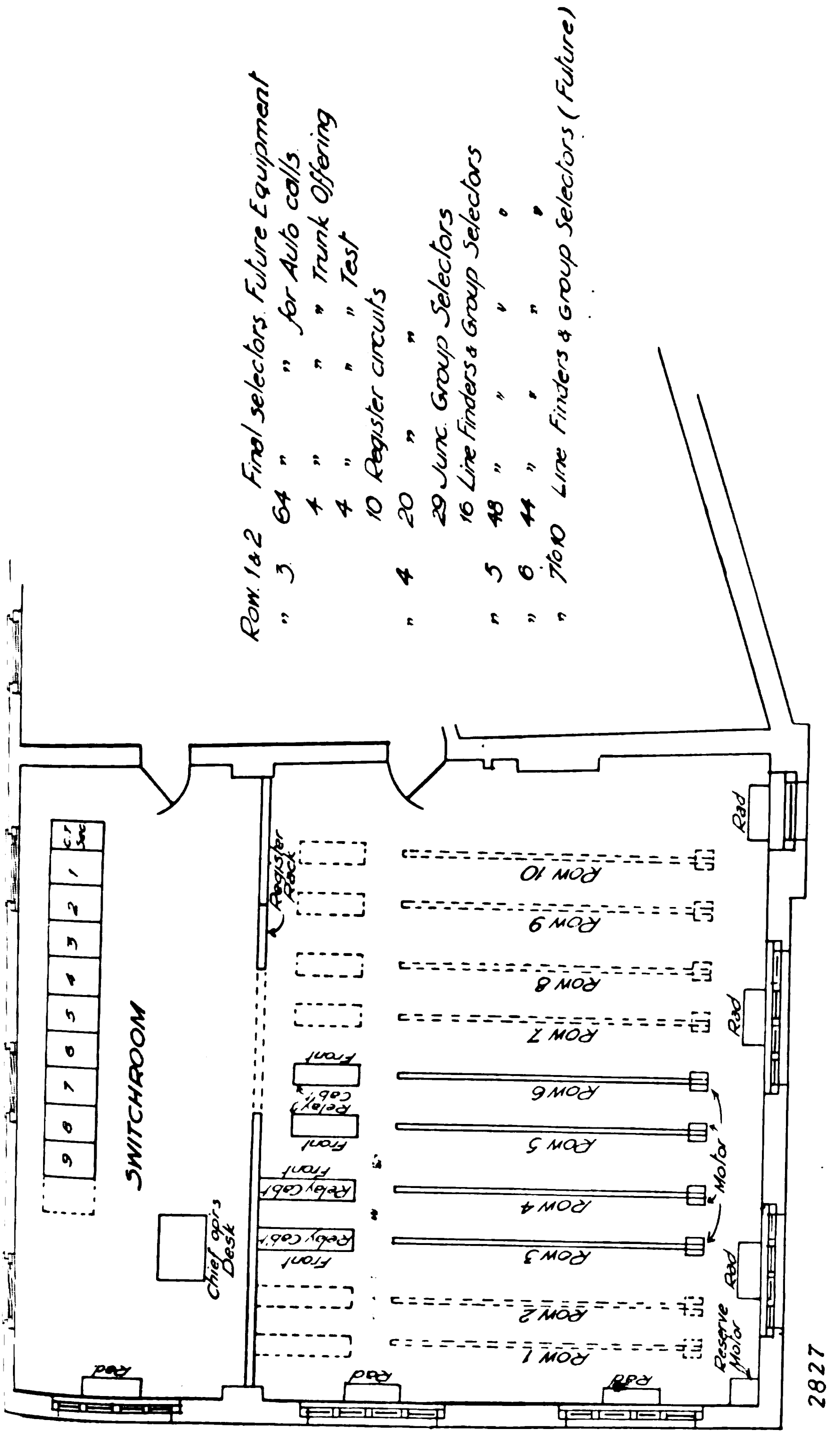
The new equipment provides for combining these two exchanges by means of automatic equipment for the local service and a manual board for the "long distance" traffic. The "long distance" circuits will be re-arranged to work on a junction signalling basis when connected to the automatic equipment, *i. e.*, through-signalling will be afforded from the automatic subscribers to the distant trunk or long distance centre controlling the call, thus providing improved operating facilities.

The automatic equipment has been designed for a capacity of 2800 subscribers ultimately and 800 initially, and the manual switchboard which accommodates the local junctions and long distance circuits, provides for 9 positions initially and 10 ultimately. The exchange is accommodated in a new post office building, which was originally planned for a manual equipment. The space amply provides for the needs of the automatic plant, with facilities for

DARLINGTON AUTOMATIC EXCHANGE.



I.—Darlington Exchange Lay Out.



PART SECOND FLOOR PLAN

2.—Darlington Exchange Lay Out.

providing for an exchange with a larger ultimate capacity than would have been possible under manual conditions, but the lay-out is not ideal. It was not possible to locate the automatic switches in the same room as the test desk, main frame, etc., which is of course preferable from a maintenance standpoint. The power plant, main frame, intermediate frame, relay racks, and test desk are installed on the ground floor (**1**); the automatic switches and manual sections on the second floor (**2**).

It will be noticed that the subscribers' meters are fitted on a rack which forms part of the partition wall separating the automatic from the manual plant, thus enabling the operators to take the records direct from the manual switch-room.

The automatic equipment comprises:

(1) Line and cut-off relay and service meter equipment for 800 subscribers.

(2) 108 line finder and group selector circuits.

(3) 30 register circuits.

(4) 64 final selector circuits.

(5) 4 final selector circuits for testing.

(6) 4 final selector circuits for challenging numbers or offering trunk calls.

The manual switchboard provides:

(1) Positions 1, 2 and 3, for incoming traffic from distant trunk and local exchanges.

(2) Positions 4, 5 and 6 outgoing traffic to distant trunk and local exchanges.

These positions will be the trunk recording positions also.

(3) Position 7 for party line and coin box subscribers.

(4) Positions 8 and 9 for inquiry and complaints, etc.

These positions are not fitted with junction jacks in the multiple field, the space being occupied by filing cabinets for subscribers' numbers, pigeon-holes for enquiry and fault memos., and foolscap files for directory records.

3 Indicates the extent of the equipment provided in the form of a junction diagram.

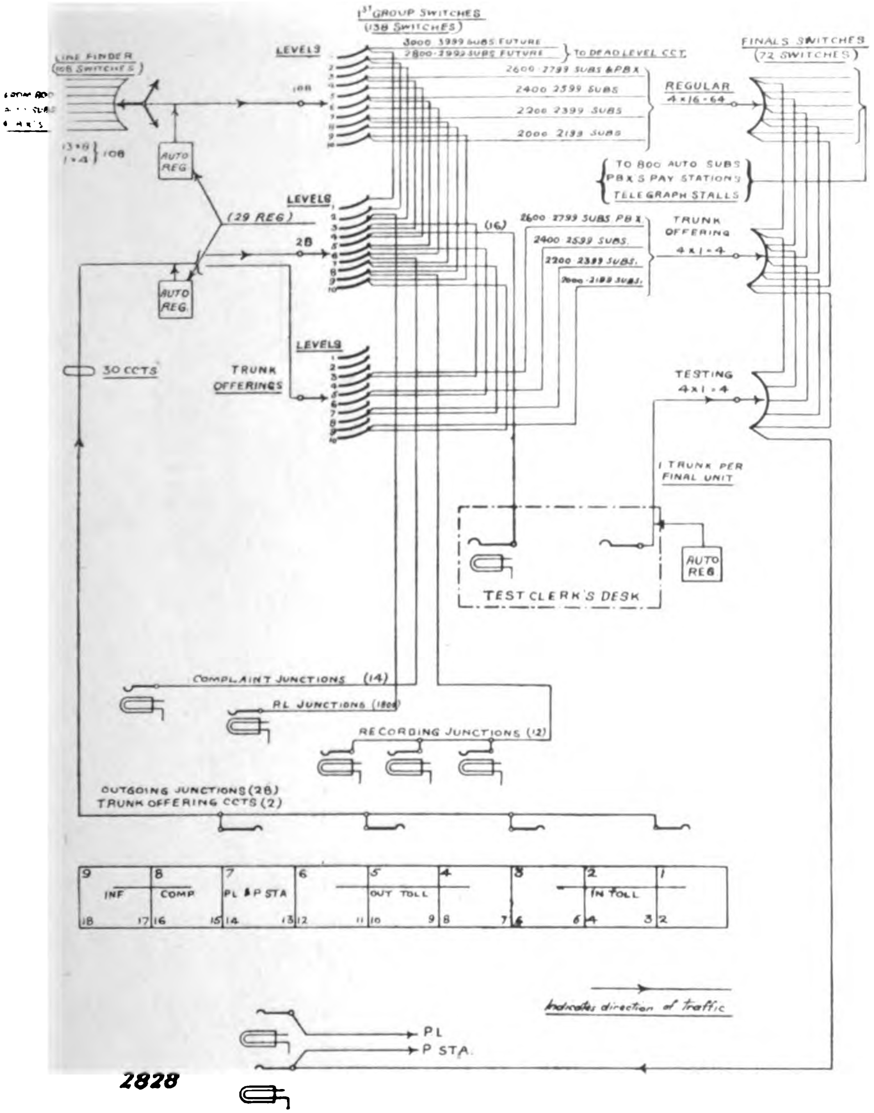
4 Shows a general view of the automatic switches mounted on row 6. There are 4 rows equipped with automatic plant, see (**2**) for equipment on each row.

5 Is a view between rows 5 and 6, and indicates the method of cabling and wiring.

The circuits to distant local and trunk exchanges will be worked as follows:—

Hurworth, Middletonone Row, Barnard Castle, Bishop Auckland, Piercebridge, Northallerton, Richmond, Stockton, West Hartlepool, and Sunderland, both-way C.B.S. junctions.

The circuits to Middlesbrough and Newcastle-on-Tyne will be segregated into direct outgoing and both-way groups.



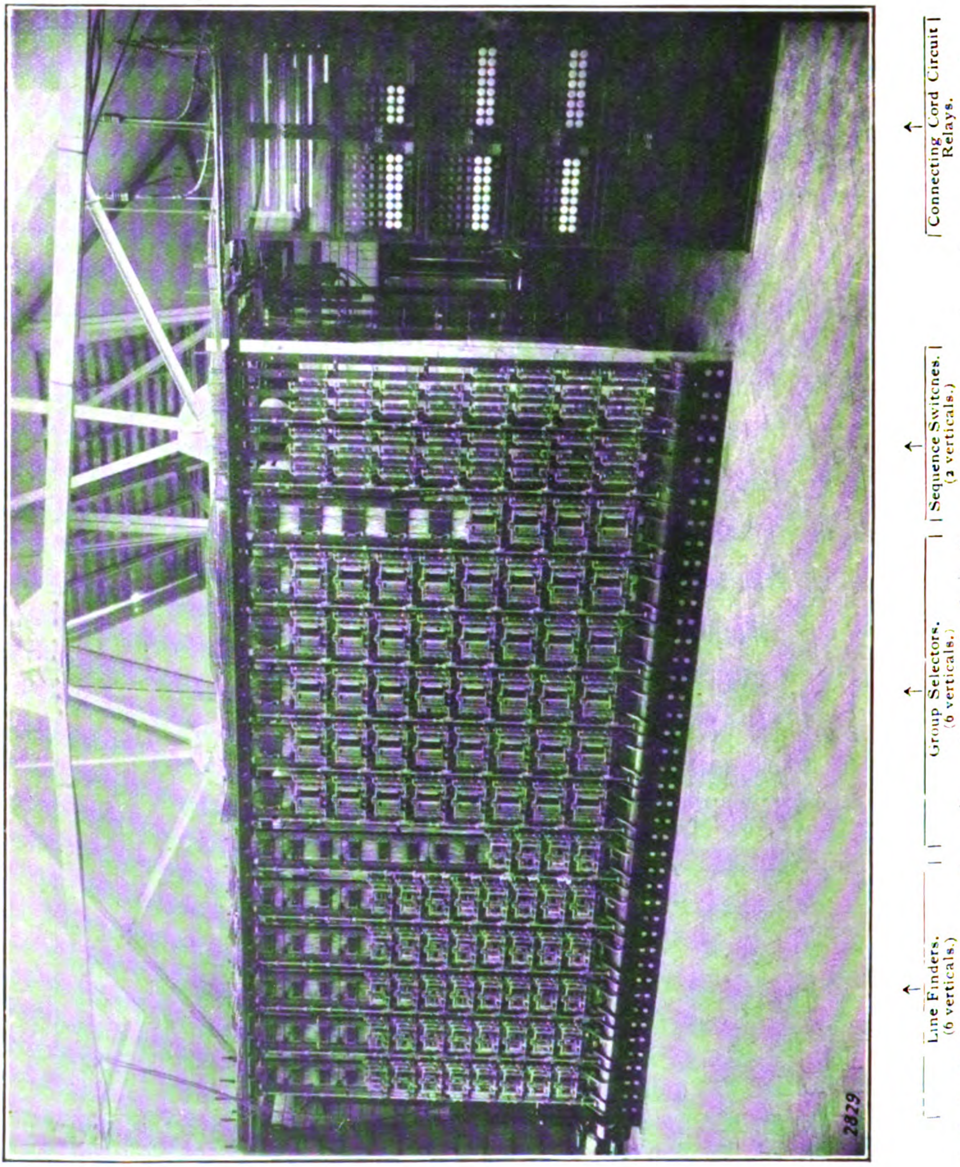
3.—Extent of Automatic Equipment, showing Outlets to and from Manual Board.

2 circuits will work outgoing to the Middlesbrough Local Exchange.

6 circuits will work both ways to the Middlesbrough Trunk Exchange.

4 circuits will work both ways to the Newcastle Trunk Exchange.
2 circuits will work outgoing to Newcastle Central Exchange.

The jack-ended junction equipment at Darlington is similar to that described by the writer for the Type 12 C.B. switchboard in this JOURNAL in October, 1912, but the incoming side of the circuits are provided with repeating coils in order that line disturbances may not be accentuated by slight variations of impedance in the apparatus


Connecting Cord Circuit Relays.
Sequence Switches. (2 verticals.)
Group Selectors. (6 verticals.)
Line Finders. (6 verticals.)
2829

of the Stone cord circuit. **6** shows the wiring of the universal cord circuit on the manual board.

Before describing the details of the plant, it will probably be helpful if the traffic conditions which have been met are referred to.

The automatic equipment is of the full automatic, two wire type for a 4-figure system, numbered from 2000 to 2799.

The subscriber's meter operates only when the called subscriber answers.

"Back release" conditions are not provided. A special alarm signal indicates when the originating subscriber leaves his receiver off, after the called subscriber has restored his telephone.

When a subscriber is engaged on a local or trunk conversation and the operator at the manual switchboard dials his number for another local or trunk connection, a "busy back" flash is received on the operator's cord current.

The ringing current is tripped immediately the receiver is lifted from the hook.

Direct ringing only is provided for automatic subscribers. All traffic to and from party line subscribers will be dealt with at the manual switchboard, where facilities for code ringing are available.

Cross-connection facilities are provided to enable the loads on each unit to be regulated as desired.

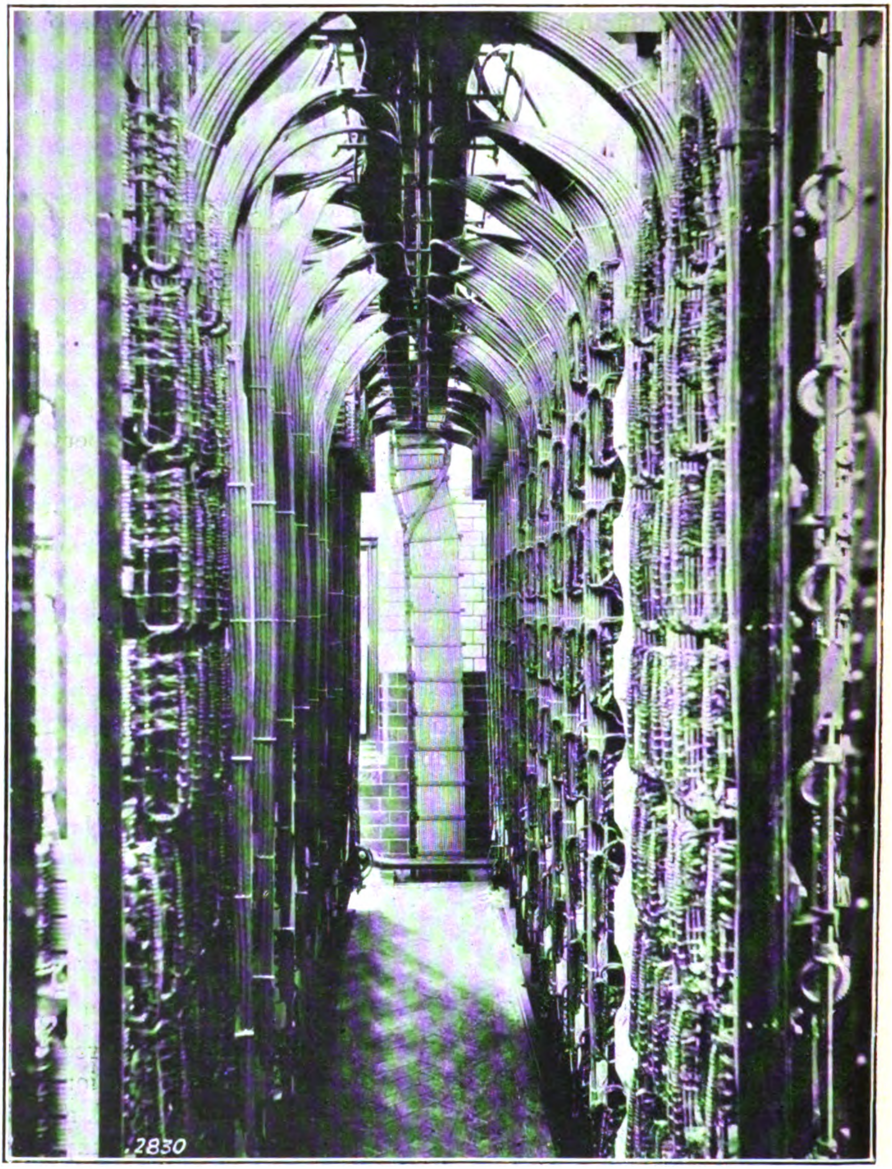
The cord circuits on the manual switchboard are of the No. 12 type, which affords through-signalling from the called subscriber to the distant exchange. The calling device provided on each position is wired in such a manner that an operator can speak on any other cord whilst dialling.

Lamp engaged signals are associated with the jacks in the outgoing junction multiple, to enable operators to appropriate disengaged circuits without the delay caused by making engaged tests. Forty jacks for circuits out-going to the automatic plant and 80 jacks for direct and both-way circuits to distant trunk and local exchanges are provided.

When an automatic subscriber desires to make a call to a distant trunk or local exchange he will dial 12, and reach a recording operator on position 4, 5 or 6; 20 jack-ended junctions are provided for this purpose. The operator will ticket the call, and if a no-delay service can be afforded the call will be at once completed in the outgoing junction multiple. The meters of automatic subscribers do not operate on these connections.

When an automatic subscriber desires to make an enquiry he will dial 14 and reach the enquiry operator on position 8; 10 jack-ended junction circuits are provided for this purpose. The automatic subscribers' meters do not operate on these connections.

When an automatic subscriber desires to send a telegram he will dial 2600 and reach the telegram operator direct. These circuits are joined up as P. B. X. subscribers, so that the subscriber automatically finds an idle telegram operator. Each telegram stall is fitted with a table telephone of the automatic type to enable the

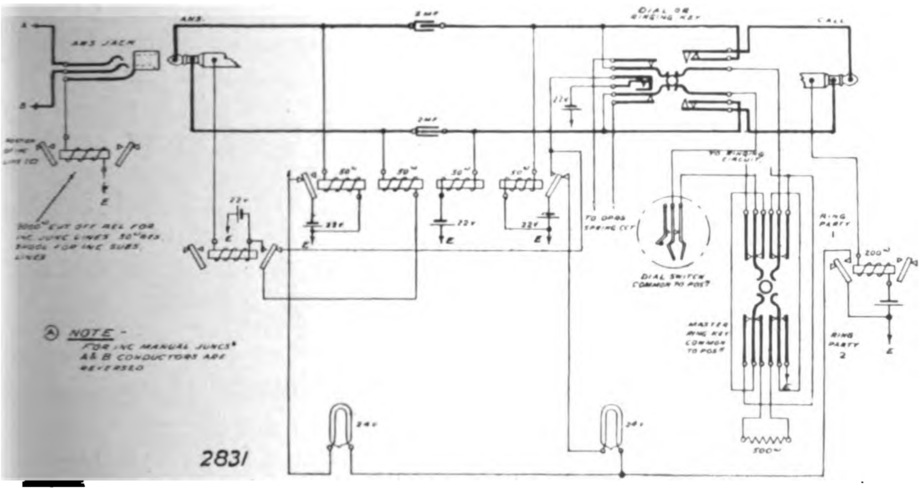


5.—Cabling and Wiring between Two Rows of Automatic Switches.

operator to dial and obtain any subscriber direct. The meter of the calling subscriber operates on successful calls only.

Eighty jack-ended junctions incoming from distant trunk and local exchanges are provided. Calls received on these circuits will be completed direct in the outgoing junction multiple. Those calls for automatic subscribers will be dealt with by means of a calling device of the finger dial type associated with the operator's cord circuit.

Each party line subscriber will be allotted a separate number in the 1800 group. These numbers do not appear in the automatic group of subscribers in the final selectors. The 3rd level of the group selectors are, however, set apart for the 1800 series, so that calls from automatic subscribers to party line subscribers will reach this level and obtain the manual board operator in a similar manner to calls for enquiry (14). The operator will then code ring the party desired. The party line circuits are joined up to separate equipment as ordinary manual C. B. subscribers, and consequently calls originated by these subscribers reach the manual operator direct on position 7.


A
B
ANS JACK
ANS.
2 MF
2 MF
DIAL OR RINGING KEY
CALL
3000~ CUT OFF REL FOR INC JUNC LINES 50~ RES SPOOL FOR INC SUBS LINES
E
22V
50~
50~
50~
50~
22V
22V
22V
E
E
E
TO OPRS SPEAK CCT
TO RINGING CIRCUIT
DIAL SWITCH COMMON TO POSN
RING PARTY 1
200~
MASTER RING KEY COMMON TO POSN
RING PARTY 2
E
Ⓐ NOTE - FOR INC MANUAL JUNCS A & B CONDUCTORS ARE REVERSED
24V
24V
500~
2831

6.—Universal Type 12 C. B. Cord Circuit Manual Board.

In the case of coin box subscribers it must be possible to allot numbers in the automatic series—2000–2799, so that any subscriber may have a coin box fitted if desired, without necessitating changing his number. This arrangement enables these subscribers to be called automatically by other subscribers. In order that originating traffic from coin box subscribers may reach position 7 on the manual board, so that the operator may supervise the insertion of the coins, special line and cut-off relay equipment is provided, and the coin box subscribers are fitted with ordinary C. B. telephones.

Position 9 is equipped with key-ended "dead number" circuits, *i. e.* lines given up, and key-ended "dead level" circuits, *i. e.* group selector levels not appropriated, so that subscribers can be promptly communicated with when errors in dialling occur, but the operators will be unable to complete connections for subscribers calling on these lines in error.

Two circuits are provided in the outgoing junction multiple to enable operators to offer trunk calls to subscribers found to be engaged, or to challenge the number of the originating automatic subscriber in the case of "no-delay" junction and trunk calls. These circuits are so arranged that the full subscriber's number has to be dialled, *i. e.*, the operator is not required to remember to pick out the trunk offering jack, associated with the particular hundred of the automatic equipment, and dial the tens and units digits only, as has hitherto been the case. The latter method imposes an operating condition liable to be overlooked, and wrong number corrections consequently result.

In order to grasp the sequence of operations effected in the Western Electric Company's system, it will be helpful to students of automatic telephony if the ideas of the circuit operations and the mental pictures formed by the study of the "Strowger" type of automatic exchange are abandoned. The main differences are :

(*a*) The system is power-driven.

(*b*) The calling subscribers' line is found by idle automatic switches; eight are provided for each sixty subscribers.

(*c*) Rotary switching mechanism *only* is used for completing the connection from the calling to the wanted subscriber.

(*d*) The impulses sent by the subscriber's dial are received and stored by a special counting device termed a "register." The latter then controls and directs the movement of the group and final selectors by what is now well known as the reverting impulse control method. Thirty registers are provided for this purpose. The registers are cut out of the circuit when the called line is connected.

(*e*) Second selectors are not used on this equipment at present, as the register circuit arranges to combine the 1000's and 100's digits received in such a manner that the trip spindle of the group or first selector (referred to later) obtains connection with the desired level accommodating the trunks outgoing to the final selector or connector.

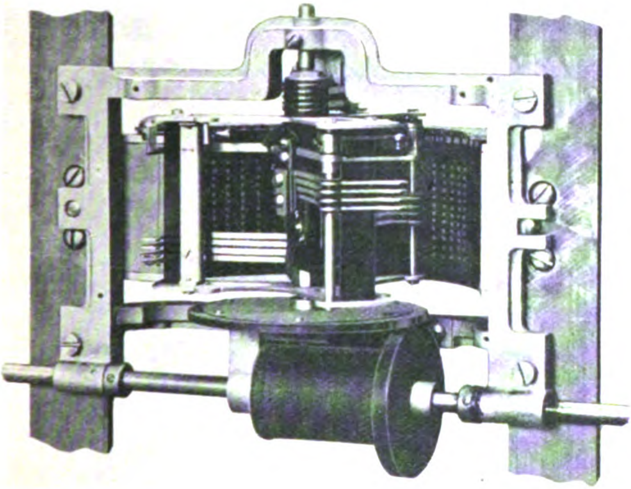
(*f*) The register circuit also transmits the 10's and units digits to the final selector; the former digit determines the level to be tripped, and the latter steps the brushes to the units of the correct hundred, *i.e.* the even or odd hundred on the final selector.

(*g*) The final selectors accommodate 200 subscribers' lines per unit (20 circuits per row) instead of 100 (10 circuits per row), and the group selector accommodates 22 trunks to final selectors instead of 10 in other systems, which is a distinct advantage from a traffic point of view.

(*h*) A 24-volt battery is used for the talking circuits throughout the equipment and for signalling on the manual board, and a 48-volt battery for the signalling circuits on the automatic plant.

It will be observed that methods (*a*), (*b*) and (*c*) are similar to those used in the Lorimer type of automatic exchange described in this JOURNAL in July last, Vol. 6, Part 2.

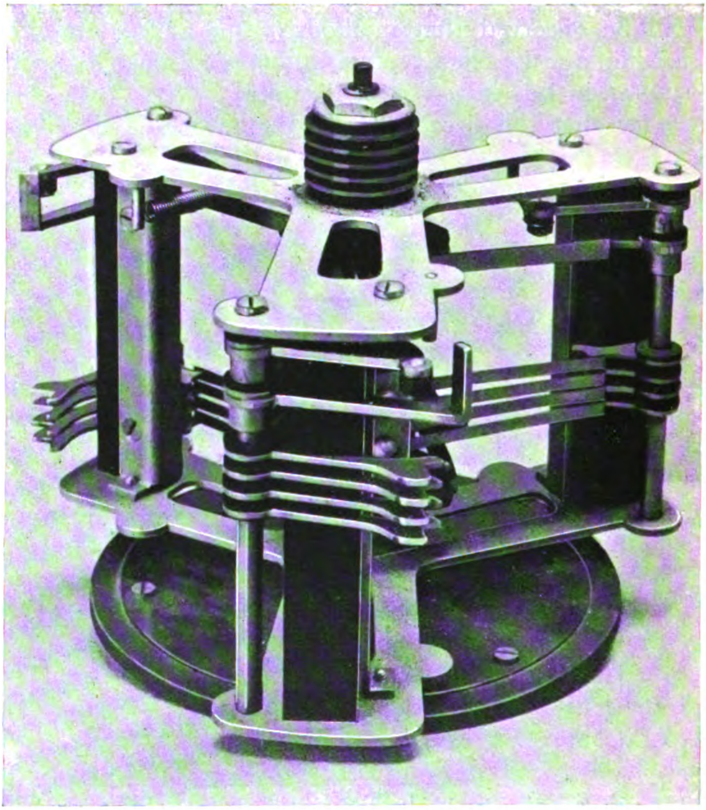
In order that the description of the automatic circuits may be grasped more readily, a brief description of each of the essential pieces of automatic apparatus will prove helpful. The whole of the automatic switches are mounted on racks, fitted with vertical and horizontal driving shafts, geared together by bevel-gear wheels, and maintained in continuous rotation by motors driven from the supply mains.



7.—LINE FINDER.

7 and **8** show a LINE FINDER. This device has 240 terminals—20 horizontally and 12 vertically—for 60 subscribers' lines. Each subscriber's line occupies 4 terminals, A, B, C and D vertically, as shown on page 124.

The terminals are arranged in the form of a segment of a circle, over which three sets of brushes are driven. These brushes are spaced at equal angles, so that one set of brushes enters its row of four terminals as the preceding set leaves its row. The function of the line finder is to find the calling line and to connect it with a free register. The brush-choosing mechanism, referred to later in connection with the group and final selectors, is not therefore needed as the brush carriage rotates, and all the brushes pass over their respective rows of terminals until the calling line is found.



8.—Line Finder.

Wire A 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
,, B 0 .... to 19
,, C 0 .... to 19
,, D 0 .... to 19
,, A 20 .... to 39
,, B 20 .... to 39
,, C 20 .... to 39
,, D 20 .... to 39
,, A 40 .... to 59
,, B 40 .... to 59
,, C 40 .... to 59
,, D 40 .... to 59

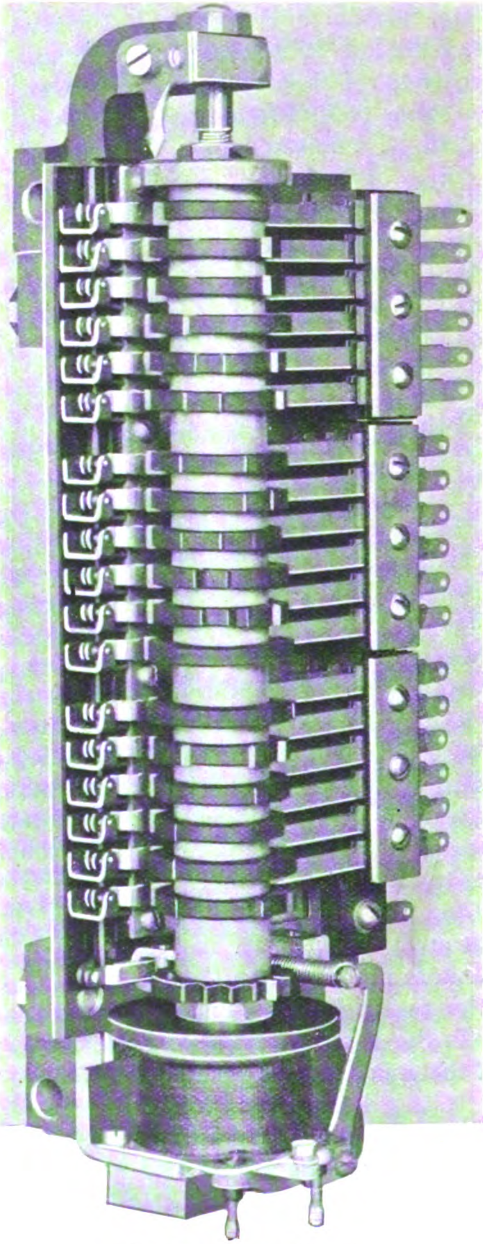
For each group of 60 subscribers, 8 line finder switches are provided at Darlington. The brushes on each switch are set opposite different subscribers' terminals. For each call originated by one of the 60 subscribers, all idle line finders in the group rotate, and immediately one of the line finders finds the calling line, the remaining line finders cease to rotate. This method ensures that when two subscribers in the same group of 60 lines call the exchange simultaneously each shall be connected to a separate set of automatic switches.

9 and **10** show a SEQUENCE SWITCH, which together with relays governs the action of the REGISTERS, GROUP SELECTORS, and FINAL SELECTORS. The register circuit is used for receiving the impulses from the subscriber's dial, and controls the movements of the group selector and final selector in order to obtain connection with the circuit desired.

The sequence switch is an outstanding feature of the Western Electric system, and it is difficult to imagine the large number of combinations of ordinary relay circuits which would be needed if this apparatus was not available. The sequence switch which has been described as a mechanical relay, consists of a spindle fitted with a clutch magnet, which acting through a series of ebonite cams, governs the actions of spring contacts. The cams are cut to three different depths so that each spring contact can be thrust into three different positions, pressed against the inner contact, the outer contact, or suspended between the two. The order in which the various contacts open and close is also entirely dependent upon the cams. The teeth on the star wheel shown just above the friction wheel correspond to the positions in which the sequence switch spindle is to rest. The "a" contacts seen in circuit diagrams are controlled by this star wheel, and are connected with the magnet in such a manner that the spindle comes to rest in the correct position only.

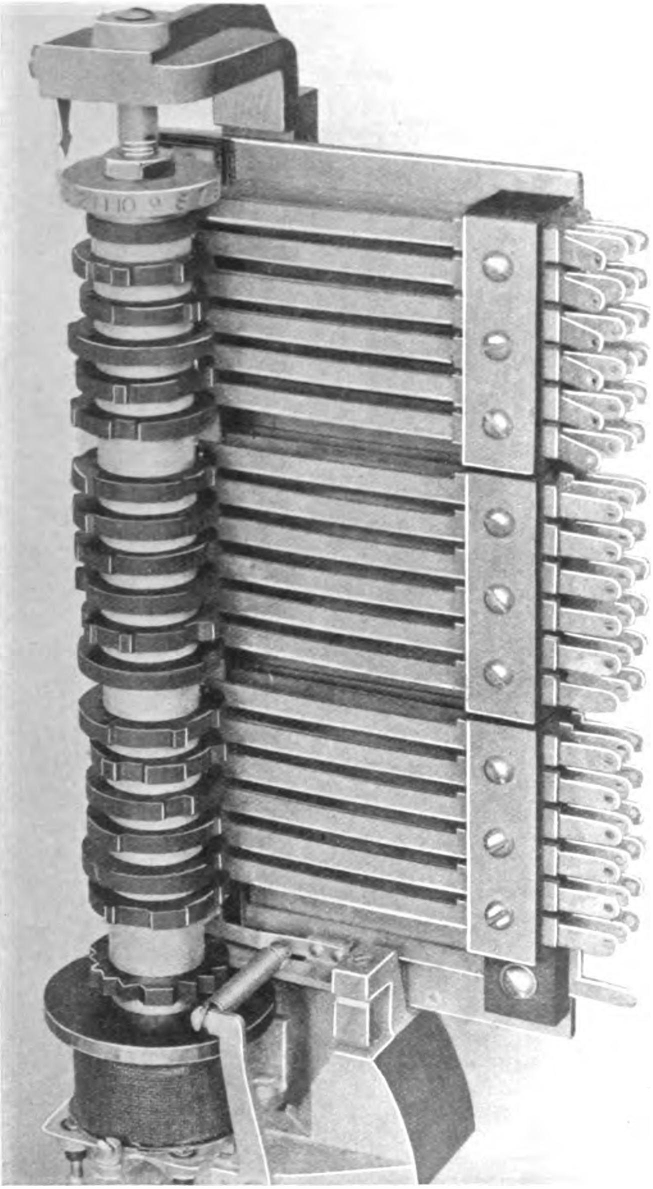
The duration and rate of the make and break of the spring contacts is dependent upon the speed of the power drive, which can be relied upon to be more uniform than the operation of relays. It is stated to be for this reason that sequence switches are used to control all the apparatus in the Western Electric Company's system. The dial at the top of the spindle indicates the position of the sequence switch contacts.

11 shows TWO-GROUP SELECTORS, which resemble the line finder as regards construction, but the former has 660 terminals, 22 horizontally and 30 vertically, for 220 circuits, and each line occupies 3 terminals vertically, see **12** and **13**. There are 30 brushes in 10 sets of 3 each, one brush for each row of terminals. The brushes, which are locked so that they cannot touch the terminals normally, are assembled in a frame known as a brush carriage. A brush-choosing device is fitted for releasing the set of brushes desired and allowing them to rotate over the row of terminals associated with the desired



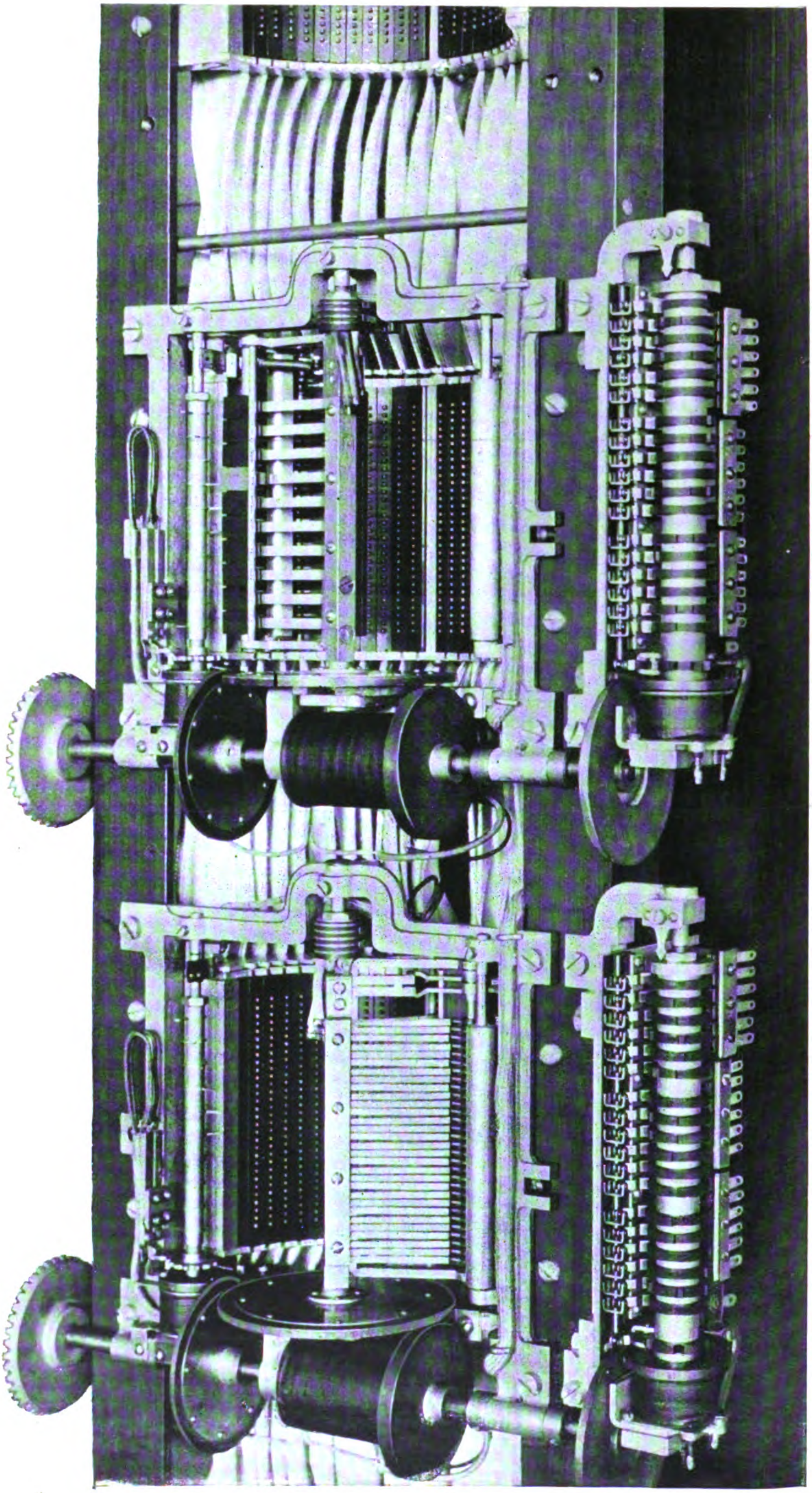
9.—Sequence Switch.

selector levels. The choosing of levels is effected, firstly, by an ebonite latch which holds back a spring associated with the brushes (one latch governs three brushes), and secondly, by a trip spindle which disengages the latch associated with the set of brushes desired,



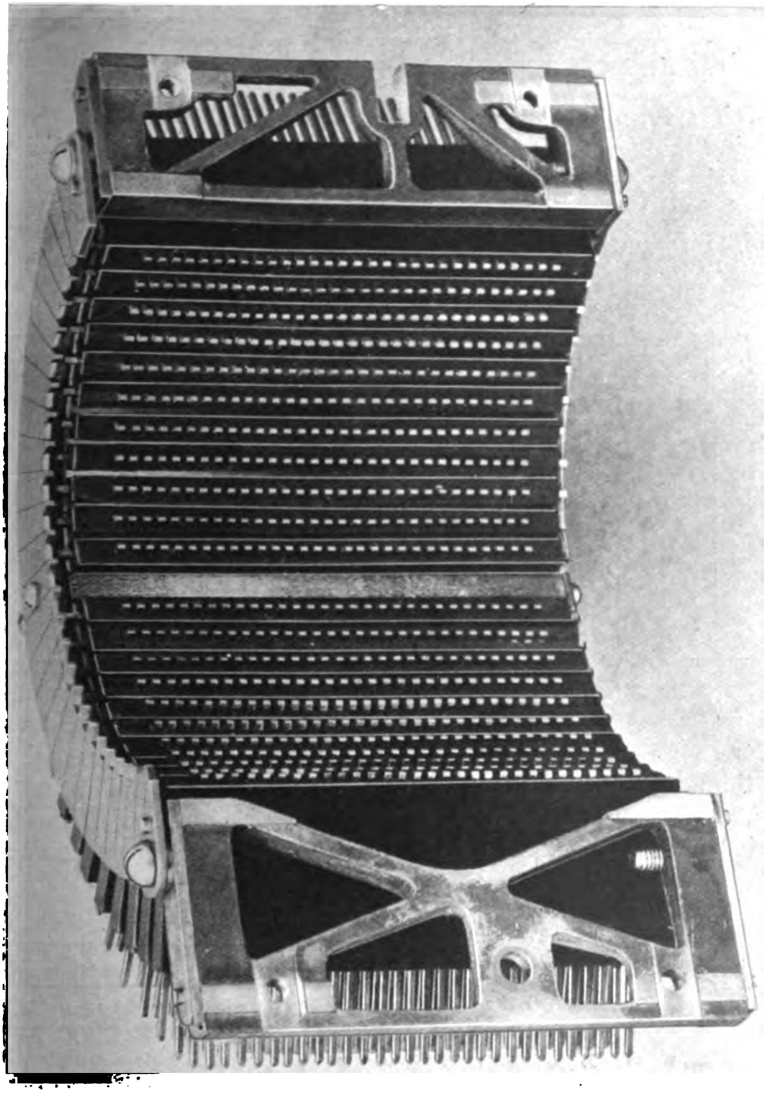
10.—Sequence Switch.

see **14**. As shown in **15** the trip spindle is fitted with 10 projecting springs mounted spirally; these projections are used to release the



II.—2-Group Selectors

latches as the brush-carriage rotates and so allow the brushes to make contact with the terminals. The trip spindle is rotated independently from the separate power plate shown, and can be set by the register in any position and so select the level 0, 9, etc., downwards to 1 as desired. Above the power-plate the edge of a star wheel is shown bearing against a roller which governs spring contacts. The contacts make and break the register circuit by which the trip spindle is adjusted, to release the set of brushes of the desired level. Each notch of the star wheel corresponds to a position of the trip



12.—Group Selector Terminal Arc.

spindle for releasing a set of brushes. When the brushes return to the home position after the completion of a call, they are restored to normal by passing over the roller contact shown at the right of **14**. The contact portions of the brushes are arranged so that they pass forward without placing adjacent terminals in contact. The brush-carriage rotates by means of a separate magnetic clutch and power-plate. The latter is fixed to the shaft of the brush-carriage and the pole piece and core are fixed to the power shaft as shown in **16**. The terminals of the group selector are associated with circuits outgoing to final selectors. As there are 22 circuits on each level, the efficiency of these group selectors is superior to the usual first, second, or third selector in other systems, which accommodate 10 circuits only on each level.

The allocation of the levels on the group selectors at Darlington is as follows:

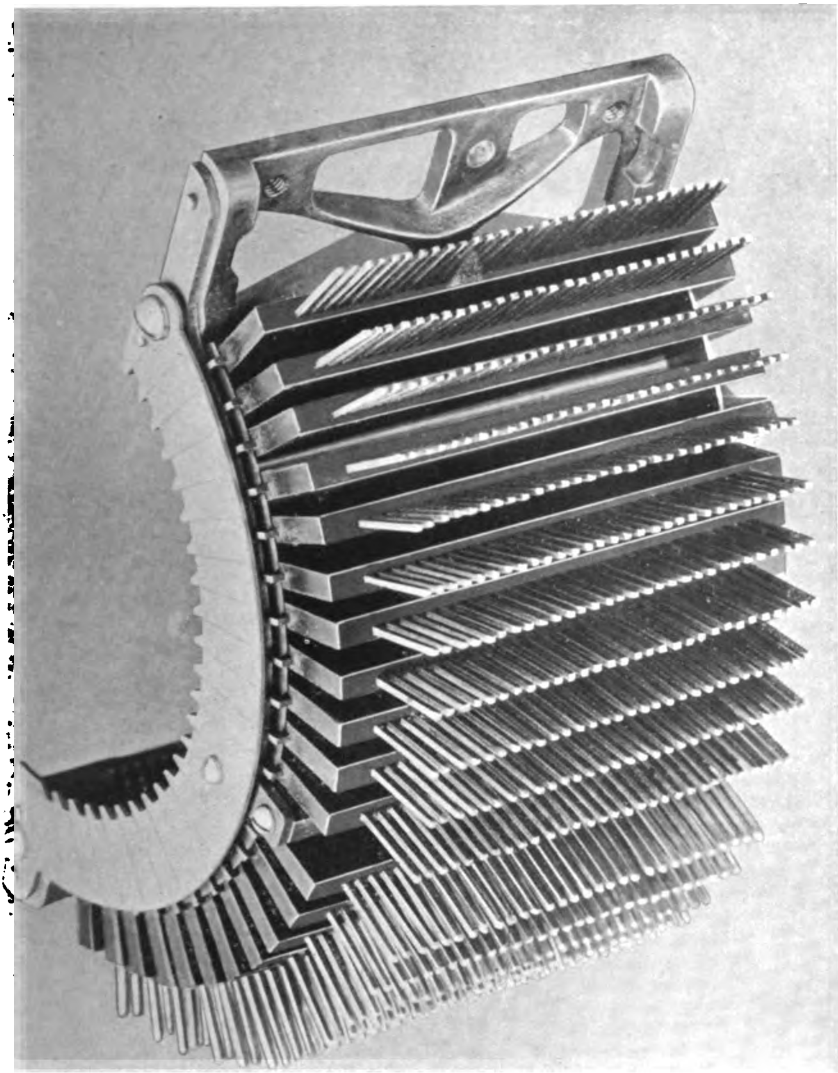
Level No.	Circuits associated.	Numbers dialled.
1	Dead-level circuits, manual board . .	3000 to 3999 (future equipment)
2	Ditto	2800 to 2999 („)
3	Party lines, manual board . . .	1800 to 1999
4	Final selectors for P.B.X. and ordinary lines	2600 to 2799
5	Test lines. Test clerk's desk . . .	16
6	Final selectors for ordinary subscribers .	2400 to 2599
7	Enquiry lines, manual board . . .	14
8	Final selectors, ordinary subscribers. .	2200 to 2399
9	Trunk records, manual board . . .	12
10	Final selectors, ordinary subscribers .	2000 to 2199

The FINAL SELECTOR accommodates 200 lines, and is exactly similar in construction to the group selector. There are 10 levels, one for each of the tens' digits of the particular hundreds associated with the final selector, and 20 terminals on each level. The first 10 terminals are connected with the units' digits of the odd hundred associated with the final selector, and the second 10 terminals are

Typical Numbering of Lines in Final Selector 2200–2300.

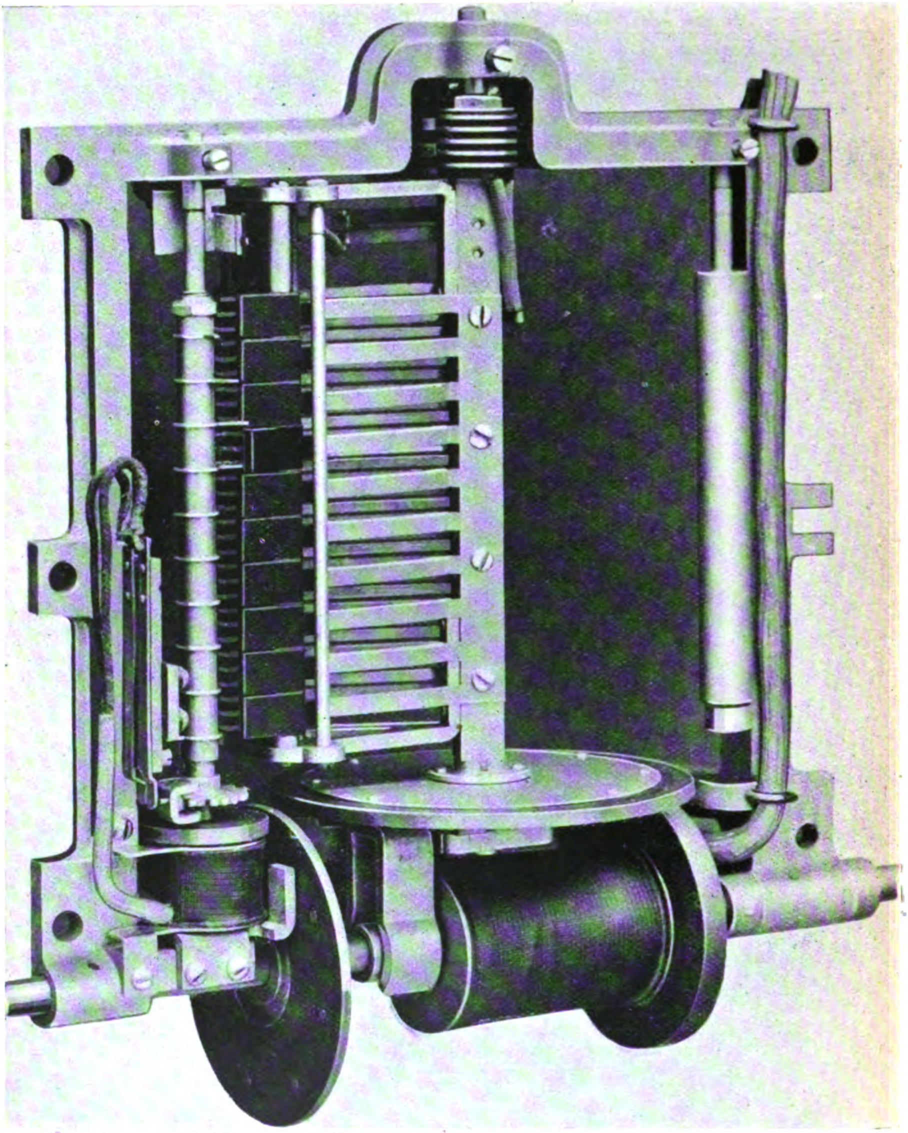
Level No.	Numbering of final selector banks.	
	Terminals for odd 100's.	Terminals for even 100's.
1	2300, 09, 08, 07, 06, 05, 04, 03, 02, 01	2200, 09, 08, 07, 06, 05, 04, 03, 03, 01
2	2390, 99 91	2290, 99 91
3	2380, 89 81	2280, 89 81
4	2370, 79 71	2270, 79 71
5	2360, 69 61	2260, 67 61
6	2350, 59 51	2250, 59 51
7	2340, 49 41	2240, 49 41
8	2330, 39 31	2230, 39 31
9	2320, 29 21	2220, 29 21
10	2310, 19 11	2210, 19 11

connected with the units' digits of the even hundreds on the final selector, *e.g.*, in the final selector for the 200 subscribers' circuits in the 2200 and 2300 series, 2272 and 2372 are on the same level, as each have the same tens' digit. The latter being an odd hundred will be found on the ninth terminal of the fourth level, and the former being an even hundred will be found on the nineteenth terminal of the same level, as shown in the foregoing schedule.

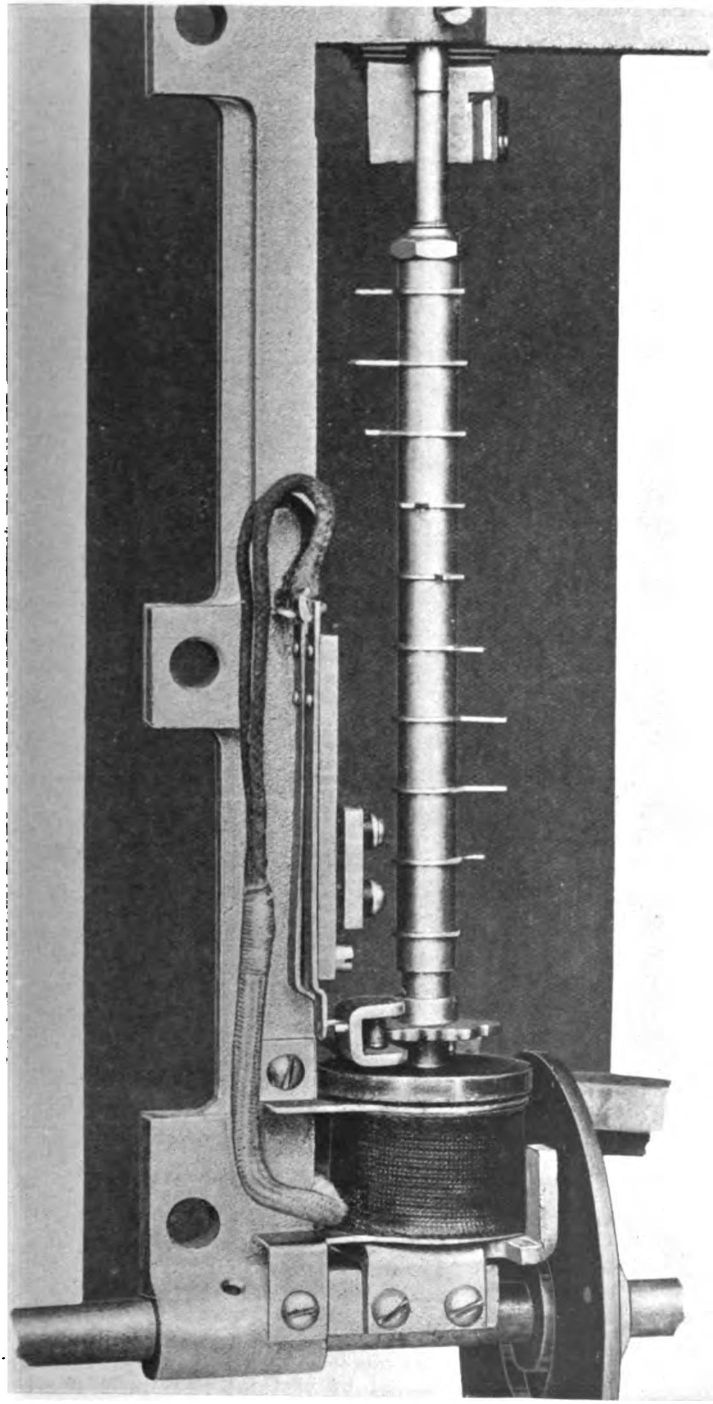


13.—Group Selector Terminal Arc.

The brush-choosing mechanism trips the brushes for the level of the correct tens digit, and the REGISTER CIRCUIT is so arranged that for the units' digits in even hundreds a second revolution (*i. e.*, an additional 10 impulses) of the units' register circuit is effected, thus ensuring connection with the desired hundred in the final selector. At the top of the brush carriage (**17**) are two contact springs bearing against a lever, at the remote end of which is a roller. This roller

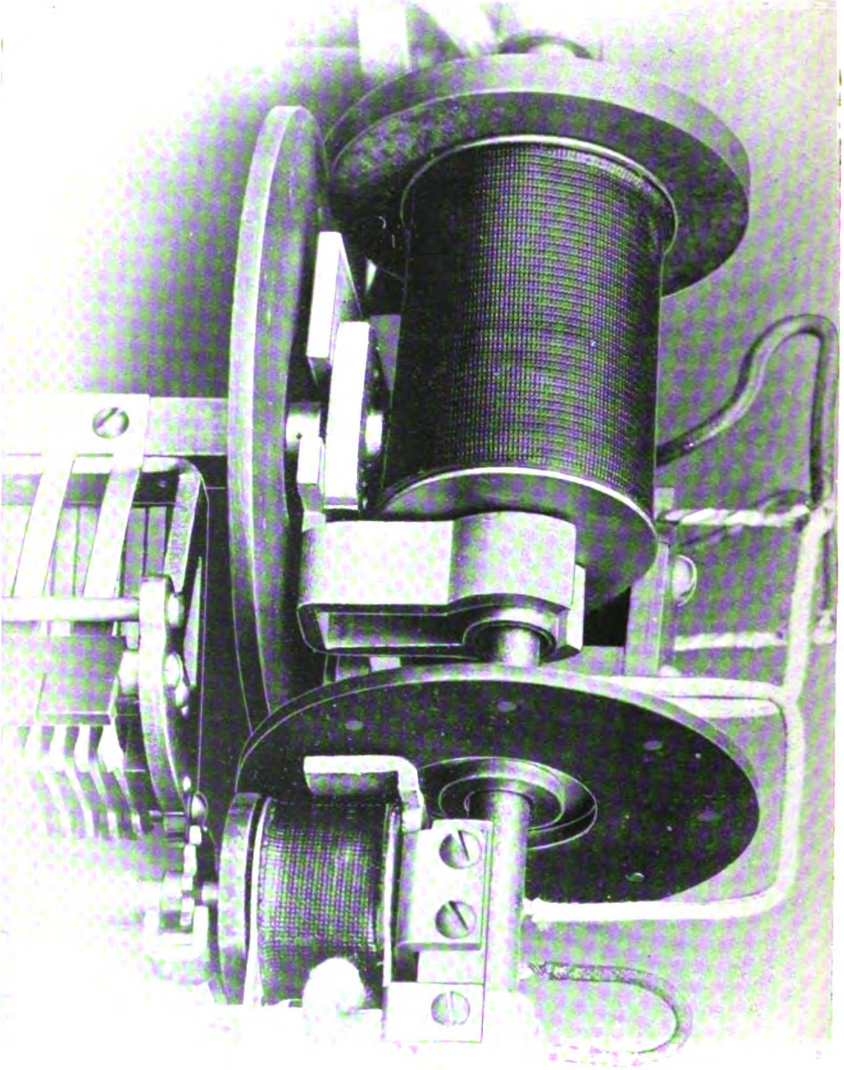


14.— BRUSH CARRIAGE.



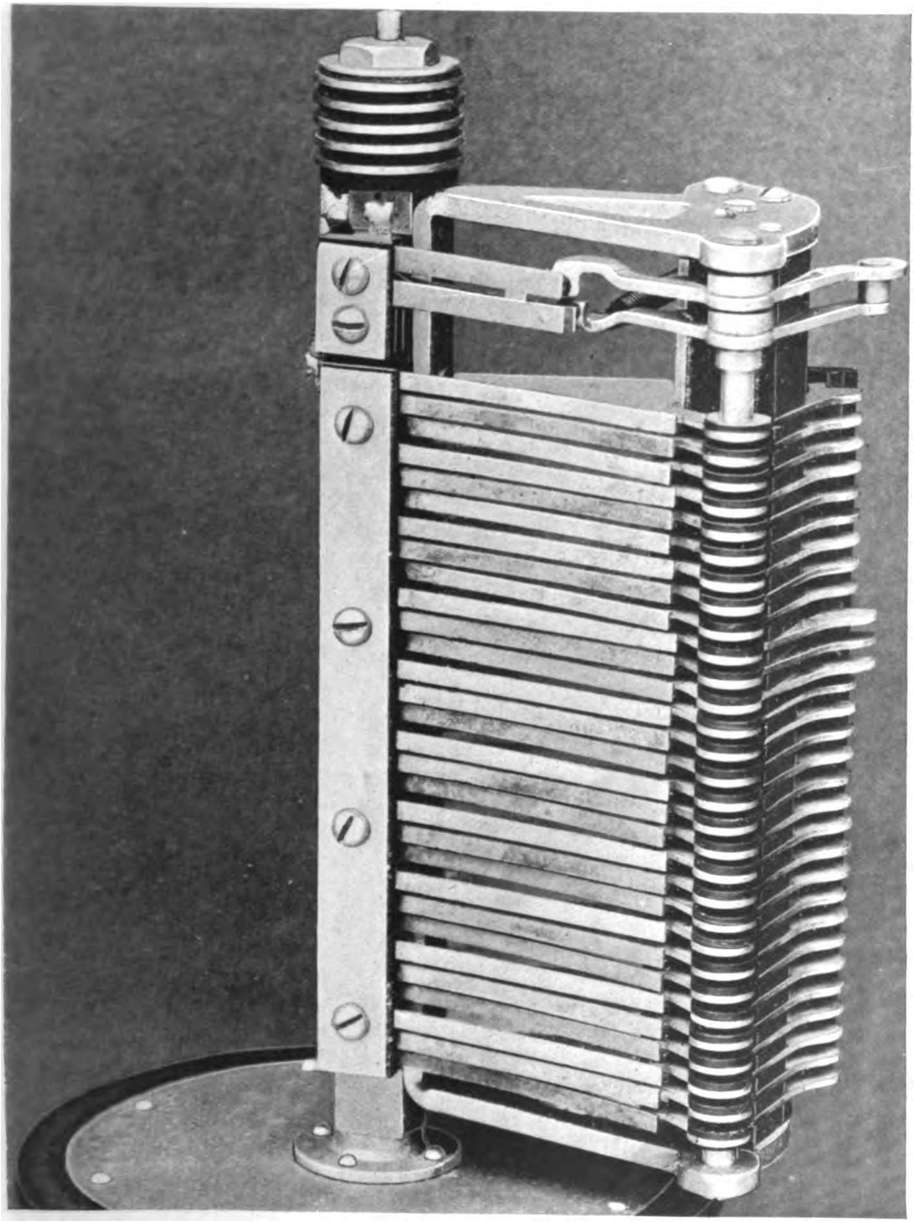
15.—Trip Spindle.

rides over the notches (**12**) and (**13**) at the top of the arc of the final selectors, and in doing so causes the two contact springs to make and



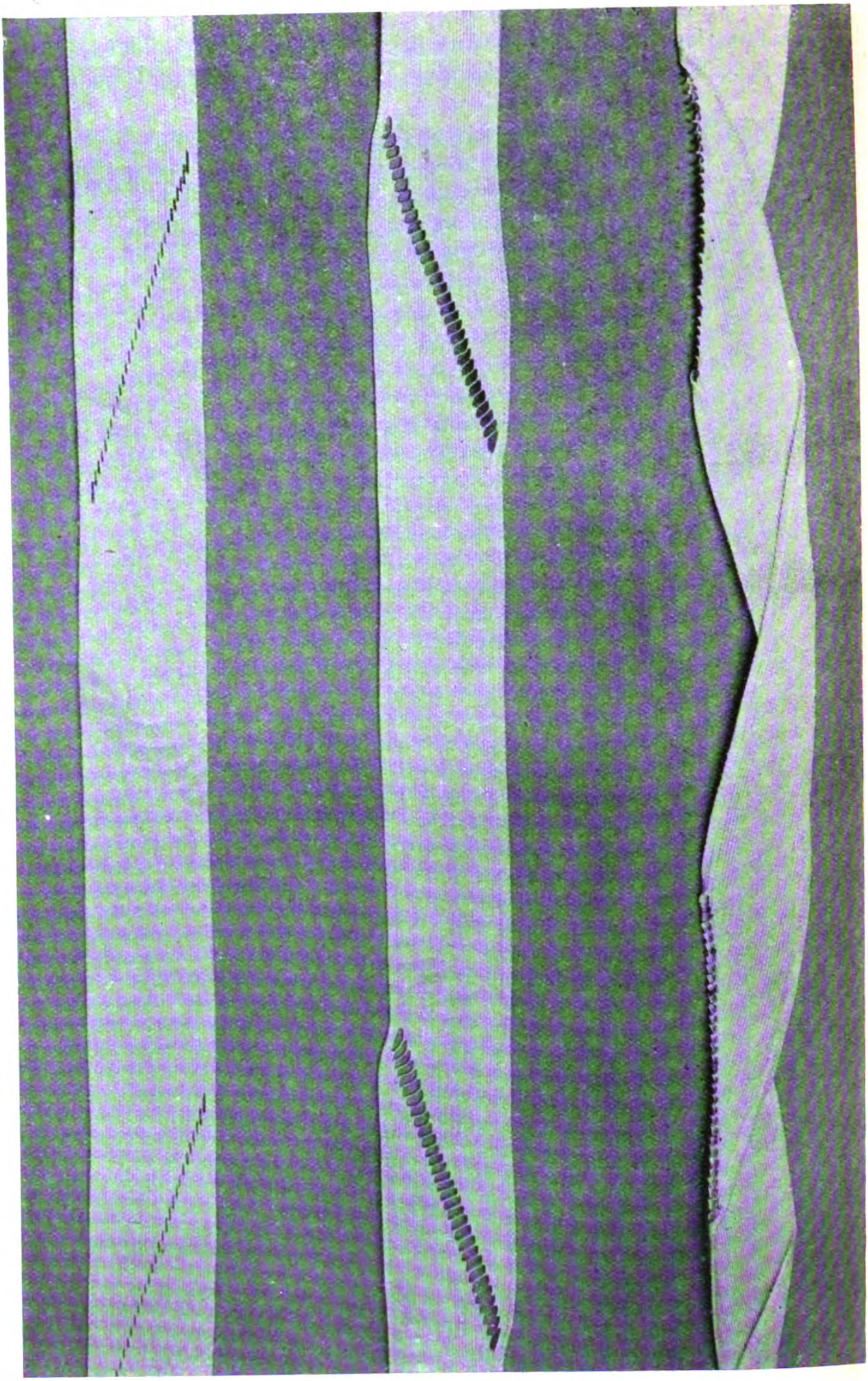
16.—Brush Carriage Magnetic Clutch.

break the circuit of the stepping relay in the register circuit. As each notch corresponds to a set of vertical terminals, the brushes are stopped on the desired set of terminals according to the number of times the two contact springs are permitted to make and break contact. Each brush bears against a spring, connected with the



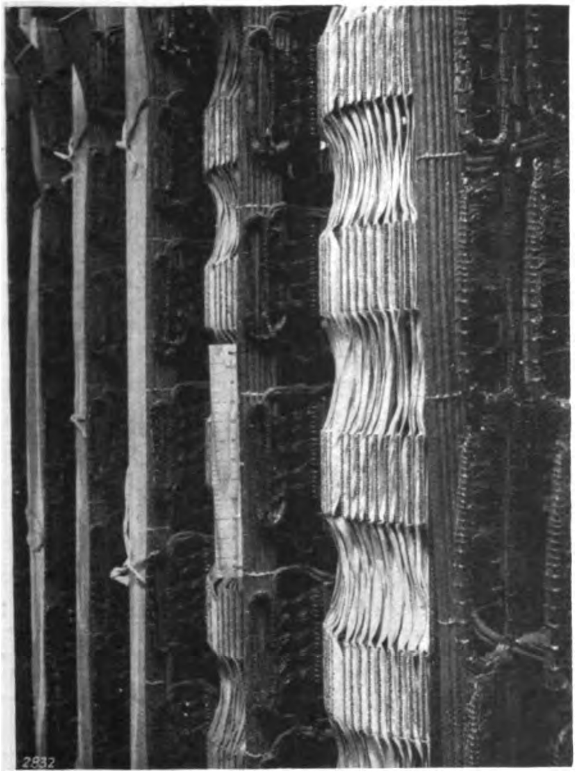
17.—Brush Carriage showing Springs Multipled to Collector Rings at top of Spindle.

spindle, and each set of three brushes is thus multipled and carried *viâ* the centre of the rotating spindle to the collecting



18.—Ribbon Multiple Cable.

rings on the top of the spindle (17). The brushes bearing on the collecting rings are neatly wired to the adjacent sequence switches. This method is also employed for the line finders and group selectors, see (8) and (14). The 200-line final selector or connector is an advantageous innovation. Compared with the 100-line connector of other systems, it has enabled the number of junctions from the group selectors to be reduced from 80 to 64 in the case of the Darlington equipment of 800 lines, as greater efficiency is obtainable with four groups of junctions to the 200-line final selectors than with eight groups of junctions to 100-line connectors.



19.—Ribbon Multiple Cable wired to Switches.

Another new departure is introduced in connection with the multiple cabling to the line finders and selectors. The cable is made up in ribbon form (18) and consists of parallel wires insulated by woven silk. The wire is left bare in certain places; the exposed portions of the cable correspond to the positions of the terminals on the automatic switches. At these points the wires are simply drawn over the terminals and soldered (19), instead of the usual laborious method of cutting and forming out the multiple switchboard cables. This novel scheme of cabling is simple, inexpensive, and easy to instal; in addition the terminals and soldering are always open to inspection and readily accessible. From a maintenance standpoint the conditions appear to be highly favourable.

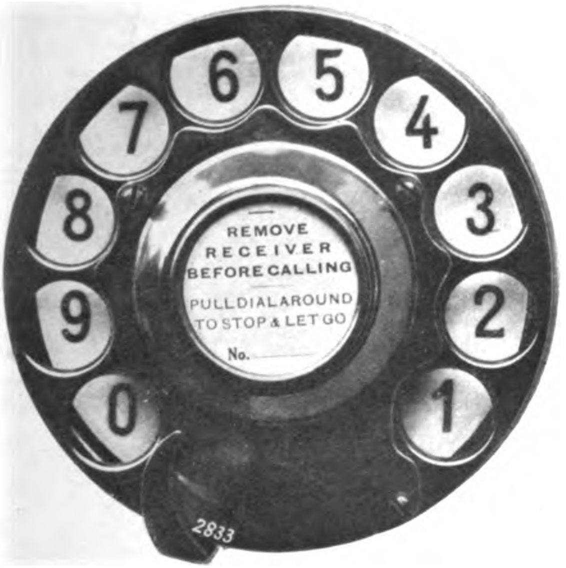
The subscriber's instrument is of the standard C.B. type, with which is associated a calling device of the finger dial pattern, precisely similar in appearance to the Strowger dial, *i.e.*, it is numbered 1, 2, 3, etc., to 0, from right to left (**20**). The methods adopted for rotating and governing the speed of the dial, are also similar (**21**), but the mechanical arrangements for effecting the interruptions of the line are different. (**22**), which is self-explanatory, shows in detail the scheme adopted for interrupting the line circuit, and the method of connecting the dial to the subscriber's instrument. Each figure dialled sends a series of short interruptions—caused by the small teeth on the wheel—and finally gives a long interruption. (**23**) is a rear view showing one tooth on the wheel, the fixed and moving contact springs, and the ivory operating cam for disconnecting the latter from the fixed contact spring as each tooth passes the cam. Views **21** and **23** show the essential parts associated with the mechanism of the dial, and as an inspection of these parts can be made by the removal of a few screws, the construction of the dial affords ready means for maintenance tests, inspection and adjustments.

As stated previously, the interruptions of the dial are received and transmitted by the registers; the following schedule indicates the setting and controlling of the various register circuits:

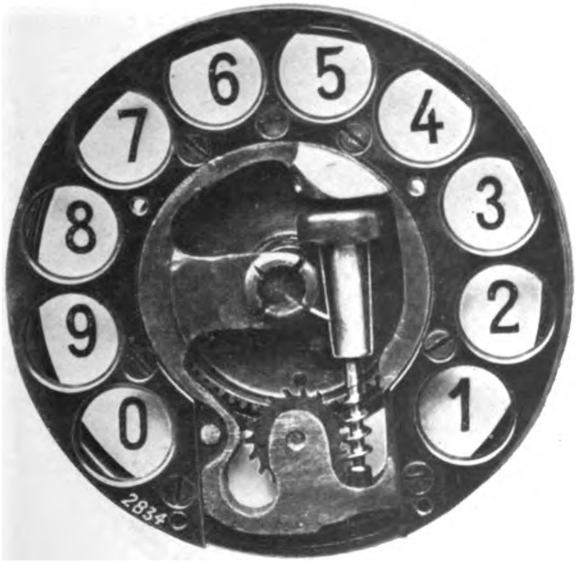
Number dialled.	Number of line interruptions.		Registers set in position.				Number of steps controlled by registers.				
	Short.	Long.	RG 1000.	RG 100.	RG 10.	RG U.	RG 1000.	RG 100.	RG 10.	RG U.	
										Odd hundred.	Even hundred.
1	*Nil*	1	2	2	1	1	2	8	9	9	19
2	1	1	3	4	2	2	1	6	8	8	18
3	2	1	—	4	3	3	—	6	7	7	17
4	3	1	—	6	4	4	—	4	6	6	16
5	4	1	—	6	5	5	—	4	5	5	15
6	5	1	—	8	6	6	—	2	4	4	14
7	6	1	—	8	7	7	—	2	3	3	13
8	7	1	—	0	8	8	—	0	2	2	12
9	8	1	—	0	9	9	—	0	1	1	11
0	9	1	—	2	0	0	—	8	0	0	10

RG 1000 has five home positions—0, 4, 8, 12 and 16. Position 0 only is the home position for RG 100, RG 10 and RG U.

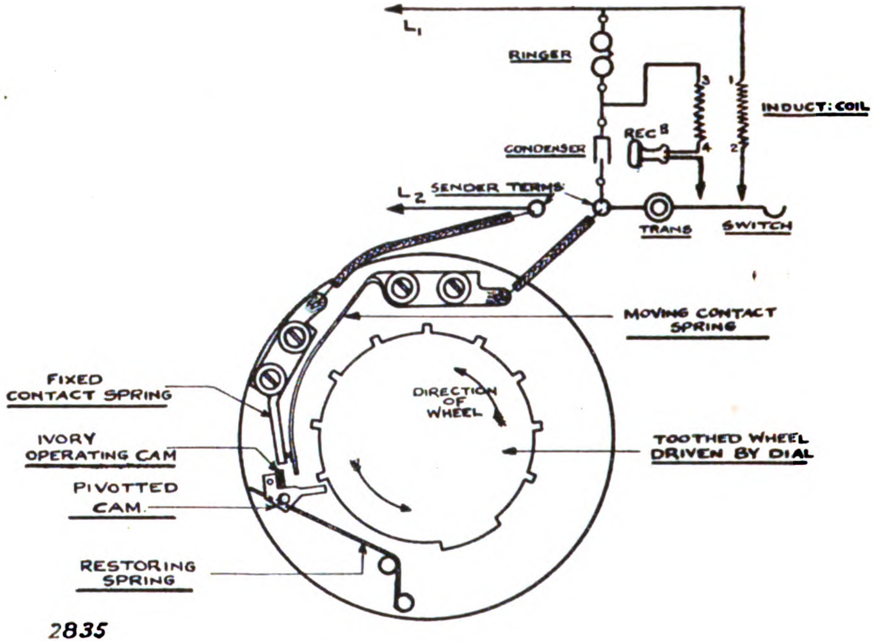
Group selector level selected = Steps controlled by RG 1000 and RG 100 + 1 step.
Final ,, ,, ,, = ,, ,, RG 10 + 1 step.
Final ,, arc terminal selected = ,, ,, RG U + 1 step.



20.—Subscriber's Dial.

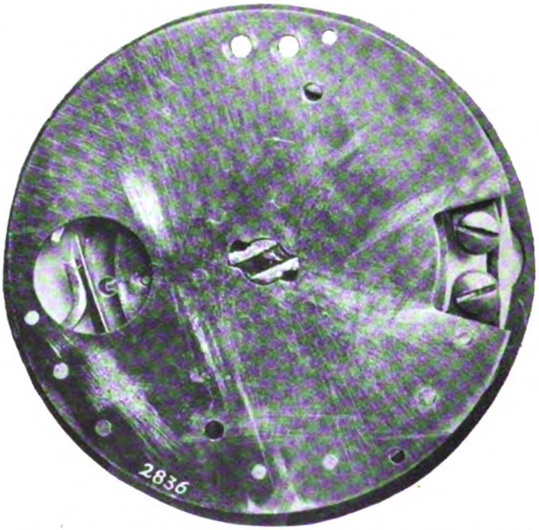


21.—Subscriber's Dial showing Governor.



EACH TIME A TOOTH ON THE WHEEL PASSES THE PIVOTTED CAM, IT PRESSES THE IVORY OPERATING CAM FORWARD, AND MOMENTARILY BREAKS THE CONTACTS.

22.—Subscriber's Dial showing Circuit Connections.



23.—Subscriber's Dial showing Interrupter Springs.

Assuming that 2272 is dialled, it will be seen from the schedule that:

RG 1000 will be set in position	3
RG 100 „ „	4
RG 10 „ „	7
RG U „ „	2

This is accomplished as follows:

When the Register Set is connected, prior to the operation of the dial by the subscriber	RG 1000 steps	1
When digit 2 is dialled, *i.e.*:		
1 short interruption	„ „	1
1 long „	„ „	*nil*
When RG 100 is being connected	„ „	1
Total		3

When RG 100 is connected, prior to second digit being dialled by the subscriber	RG 100 steps	1
When digit 2 is dialled, *i.e.*:		
1 short interruption	„ „	1
1 long „	„ „	*nil*
When RG 10 is being connected	„ „	1
When RG 100 is thus placed by subscriber in an odd position	„ „	1 (additional).
Total		4

When RG 10 is connected, prior to third digit being dialled by the subscriber	RG 10 steps	1
When digit 7 is dialled, *i.e.*:		
6 short interruptions	„ „	6
1 long interruption	„ „	*nil*
Total		7

When RG U is connected, prior to fourth digit being dialled by the subscriber	RG U steps	1
When digit 2 is dialled, *i.e.*:		
1 short interruption	„ „	1
1 long „	„ „	*nil*
Total		2

As previously stated, the registers control the group and final switches. It will be seen from the group selector schedule that the junctions to the 2200 and 2300 subscriber's final selector are on the eighth level. This necessitates combining the RG 1000 and RG 100 circuits to run concurrently in order to set the trip spindle to trip the brushes for the eighth level. RG 100 circuit first steps around 6 times to its home position, *i. e.*, from 4 to 0, and then RG 1000 makes one step to its home position, *i. e.* from 3 to 4, 7 steps only, but when the register circuit is changing over from the group selector to the final selector, the trip spindle makes one additional step, thus bringing the total required to 8. The final selector is controlled first by RG 10, which steps 3 times to its home position, *i. e.*, from 7 to 0, and the trip spindle moves one extra place, when the RG 10 is changed over to RG U, *i. e.*, 4 steps, or the fourth level, which sets the trip spindle correctly for the lines from 70 to 79, see numbering schedule for final selector. (**14**) shows the trip spindle tripping the brushes on the fourth level. RG U now steps 8 times to its home position, *i. e.*, from 2 to 0. In this position its magnet is again energised and again starts to rotate, for when an even hundred is dialled, as in this case, a second revolution of RG U is necessary in order to reach the units' digits of the even hundreds, which are in the second half of the terminal arcs of the final selectors. RG U, therefore, makes 18 steps, and the brushes make one additional step when the register disconnects, thus reaching the nineteenth terminal on the fourth level of the final selector 2200–2300, *i. e.*, 2272 as desired.

It will now be convenient to trace the circuit diagrams throughout the progress of a call from one automatic subscriber to another, in order to appreciate how the foregoing connections are established. Assume 2272 is called as before:

Subscriber Calling and Seeking a Free Line Finder (**24** and **25**).

(1) 24-volt battery *viâ* 1000^{ω} winding of LR, contacts of COR, subscriber's loop, contacts of COR, second 1000^{ω} winding of LR to earth. LR energised.

(2) 48-volt battery *viâ* starting relays CR, contacts of LR, 200^{ω} and 600^{ω} resistances to earth. Relays CR energised.

(3) Forty-eight volts *viâ* all relays GLR in the group, contact S1 of sequence switch R2, relay GR, contacts of relay CR to earth. Relay GR and all free GLR relays energised.

(4) Forty-eight volts *viâ* all idle line finder power magnets PF, contact E1 of R2, contacts of GT2R, contacts of GLR to earth. PF energised and each brush carriage rotates until one finds the calling subscriber's line.

Free Line Finder reaches the Calling Subscriber's Line (**24** and **25**).

(1) 48-volt circuit *viâ* CR, contacts of LR 200^{ω} and 600^{ω} to earth (see 2 above), now also completed *viâ* terminal D, brush, contact L1 of R2, 800^{ω} winding of test relay GT1R, contact K1 of R2 to earth. GT1R energised.

(2) Above circuit now completed *viâ* 15^{ω} winding and contacts of GT1R, contact N1 of R2 to E *viâ* home contact of interrupter FINT.

(3) When the line finder is centred on the terminals of the line FINT opens, and above

circuit completed *viâ* test relay GT2R, contact G1 of R2 to earth. GT2R aperates and disconnects PF. All line finders cease to rotate.

(4) Forty-eight volts *viâ* R2, contact C1 of R2, contacts of GT2R and GLR to earth. Holding magnet HF energised in parallel *viâ* contact B1 of R2, and brush carriage stops. R2 also energised and all its contacts pass from position 1 to position 3, disconnecting relay GR and HF.

(5) Relay GLR now remains energised *viâ* contact R3 of R2, 500^{ω} resistance, contact F1 of sequence switch R1 to earth.

(6) Terminal D is now connected direct to earth *viâ* contact K3 of R2, thus disconnecting test relays GT1R and GT2R. Contact K3 of R2 makes before contact L2 of R2 breaks.

(7) Forty-eight volts *viâ* COR and meter SM in parallel, terminal C, contact L1 of R1, release relay RR1, contacts of release relay RR, contact H3 of R2 to earth. Relays COR, and RR1 energised, and relays LR, CR, and GR de-energised, also all relays GLR of the other connecting circuits in the line-finder group.

(8) Twenty-four volts *viâ* repeating coil, supervisory relay S1R, contact K1 of R1, contacts of RR1, brush B, subscriber's loop, brush A, contacts of RR1, contact H1 of R1 to earth.

(9) Forty-eight volts *viâ* sequence switch R1, its contact B1, contact I3 of R2 to earth. R1 energised and all its contacts move to position 2.

FINDING A FREE REGISTER (**25** AND **26**).

(1) Forty-eight volts *viâ* sequence switch R3, contact F3 of R2, contacts of GT2R and GLR to earth. R3 rotates, and as it passes its positions ½, 1½, 2½, etc., its B contact places earth on test relay GT1R.

(2) When a disengaged register is reached, 48 volts, in parallel *viâ* 240^{ω}, lamp 1000 S, contact P1 of sequence switch R4, and *viâ* 400^{ω} resistance, and K1 of R4 to contact S1 of register sequence switch R5, contact E of R3, L3 of R2, GT1R, B of R3 to earth. GT1R energised. Supervisory lamp 1000 S now glows until dialling commences.

(3) Branch circuit now closed *viâ* 15^{ω} winding of GT1R, its contacts to relay GT2R, contact G3 of R2 to earth. GT2R operated and R3 disconnected.

(4) Forty-eight volts *viâ* R2, contact C3 of R2, contacts of GT2R and GLR to earth. R2 energised and moves to position 5. GLR thus disconnected at R5 of R2.

(5) Forty-eight volts *viâ* R1, its contact D2, I5 of R2 to earth. R1 energised and moves to position 3, releasing relays GT1R and GT2R by placing direct E on G3 of R1. When this occurs, the subscriber hears a click in the receiver followed by a tone indicating that dialling can commence. The click and tone are produced by the 48 volts *viâ* induction coil IC in the register circuit, *viâ* L1 of R4, stepping relay SR, LJ, contacts Q of R3, J3 of R1, contacts of relay RR1, brush B, subscriber's loop, brush A, contacts of relay RR1, contacts H3 of R1 to earth. Stepping relay SR energised.

(6) Forty-eight volts *viâ* sequence switch R4, its contact B1, contacts of relays MR1 and SR to earth. R4 energised and passes to position 2. Supervisory lamp RGL now glows *viâ* F of R4, and continues to glow until register set has received and transmitted the impulses.

(7) Forty-eight volts *viâ* N2 of R4, relay MR1, contacts of MR to earth. Relay MR1 energised.

(8) Forty-eight volts *viâ* RG 1000, its contact "b" position 0, contact I2 of R4 contacts and 14^{ω} winding of relay DR, contacts of relays MR1 and SR to earth. *RG 1000 makes its first step.* The branch current from 48 volt *viâ* 50^{ω} retard, 1000^{ω} winding of differential relay DR, contacts of MR1 and SR to earth, prevents relay DR from operating.

(9) After RG 1000 passes from one contact to another, "0" to "1" in this case, it closes its "a" contact and opens its "b" contact. The 14^{ω} winding of relay DR is then disconnected, and relay DR is thus energised *viâ* its 1000^{ω} winding, preventing RG 1000 moving more than one step, for one operation of SR.

Subscriber sends 1000's Digit (**25** and **26**).

For digit 2, one short and one long interruption of the line will occur.

(1) During the short interruption, relays SR and DR are energised.

(2) After the short interruption, relay SR is again energised, and then 48 volts *viá* RG 1000, its contact "b" I2 of R4, contacts and 14^{ω} winding of DR, contacts of MR1 and SR to earth. *RG 1000 moves to position 2.*

(3) Relay DR energised, as explained under "Finding a free register," item 9.

(4) During the long interruption, relays SR and DR again de-energised. The former relay now closes its back contact sufficiently long for relay MR to operate from 48 volts *viá* contact N2 of R4. This operation de-energises MR1 and energises R4, which moves from position 2 to 5, and thus prepares the dial circuit for RG 100.

(5) Lamp 1000 S is extinguished when R4 leaves position 2, and in position 3 of R4 lamp 100 S glows *viá* G3 of R4. RG 1000 is also energised *viá* O3 of R4, *thus being set in position* 3 *when figure* 2 *is dialled* as per schedule.

(6) When the long interruption is finished, relay SR is again operated, *viá* subscriber's loop, thus disconnecting relay MR and operating MR1.

(7) Forty-eight volts *viá* RG 100 its contact "b," contact I5 of R4, contact and 14ω winding of DR, contacts of MR1 and SR to earth. *RG 100 moves to position 1.*

(8) Relay DR now energised in a similar manner to that explained under "Finding a free register," item 9.

(9) In position 3 of R4, 48 volts *viá* R5, its contact C1, D3 of R4 to earth. R5 energised and moves to position 4.

(10) In position 2 of R5, 48 volts, *viá* contact R of R5, relay D1R 1000ω winding, contact of SR1 to earth, energising D1R and thus preparing the transmitting circuit of the register in order to control the group and final selectors.

Subscriber sends 100's Digit (**25** and **26**).

For digit 2 one short and one long interruption will occur.

(1) During the short interruption, relays SR and DR are energised.

(2) After the short interruption, Relay SR is again energised, and then 48 volts *viá* RG 100, its "b" contact, I5 of R4, contacts and 14ω winding of DR, contacts of MR1 and SR to earth. *RG 100 moves to position 2.*

(3) Relay DR energised, as explained under "Finding a free register," item 9.

(4) During the long interruption, the same circuits are made as those indicated in (4), "Subscriber sends 1000's digit." In this case R4 moves from position 5 to 8, and prepares the dial circuit for RG10.

(5) After R4 passes position 5, Lamp 100 S extinguished, Lamp 10 S glows *viá* R8 of R4, and RG 100 energised *viá* S6 of T4 and *moves to position 3.*

(6) Forty-eight volts *viá* R5, its contact B4, C8 of R4 contacts of relay MR2 to earth. R2 moves from position 4 to 6.

(7) As RG 100 is in position 3 (see item 5) 48 volts *viá* hundreds testing relay HTR, contact N5 of R5, contact "e" of RG 100 to earth. Relay HTR is energised and locked *viá* its front contact and J of R5.

(8) Branch current from 48 volts *viá* RG 100, its contacts "b" and "c," contact M5 of R5 to earth. *RG 100 moves to position 4*, and is thus set in the correct position for figure 2 being dialled *vide* schedule.

(9) When the long interruption is finished, the same circuits are made as those indicated in items (6) and (7) "Subscriber sends 1000's digit." In this case *RG 10 moves to position 1.*

Register controls Group Selector (**25** and **26**).

(1) Forty-eight volts *viá* GLR contacts R5 of R2, H of R3, stepping relay SR1, contacts of relay AR, F6 of R5, key CCHK to earth. Relays GLR and SR1 energised, and D1R disconnected.

(2) Forty-eight volts *viá* R2, its contact B5, contacts of GT2R, and GLR to earth. R2 energised and moves to position 6.

(3) Forty-eight volts *viâ* Group Selector trip spindle magnet P2, contact M6 of R2 contacts of GLR to earth. P2 energised and trip spindle rotates. In moving from one notch to another the bottom contact of the trip spindle interrupter INT2 rides over the teeth on the star wheel of the trip spindle and places direct earth *viâ* S6 of R2 to relay GLR, thus short-circuiting stepping relay SR1 of the register circuit for each step made.

(4) Each time SR1 de-energises, 48 volts *viâ* RG 100, its contacts "b" and "c," contact O6 of R5, contacts and 14^{ω} winding of differential relay D1R, contacts of SR1 to earth. RG 100 makes one step. The branch current *viâ* 1000^{ω} winding of D1R prevents differential relay D1R from operating until RG 100 operates. The latter also can only make one step each time SR1 is de-energised, as it is controlled by D1R in a similar manner to that outlined in item (9). "Subscriber sends 1000's digit."

(5) When RG 100 reaches its home position "0," *i.e.*, 6 steps from 4 (the position in which it was set when 2 was dialled) to 0, the trip spindle will have moved from the number 0 notch to the sixth notch.

(6) RG 100 then disconnected, and 48 volts *viâ* RG 1000, its contacts "b" and "c," contact "d," number 0 of RG 100, contacts O6 of R5, etc., to earth, as in item 4 above. RG 1000 thus moves to its home position 4, *i.e.*, 1 step from 3, the position in which it was set when 2 was dialled.

(7) The trip spindle will now be in the seventh notch, and on reaching the eighth tooth and again de-energising SR1, 48 volts in parallel *viâ* R5, and relay AR, to contact G6 of R5, contact "d" of RG 1000, contact K6 of R5, contact "d" of RG 100, contact O6 of R5, etc., to earth. R5 moves to position 7, and AR operates and disconnects SR1.

(8) When the trip spindle reaches the eighth notch, GLR is also disconnected, P2 is then released, and the trip spindle is thus set to trip the brushes for the eighth level as desired, to reach one of the 16 junctions outgoing to the final selector of the 2200 group of subscribers' lines.

(9) When SR1 released, relay D1R operates and disconnects AR and R5.

(10) Forty-eight volts *viâ* R2, its contact C6, contacts of GLR to earth. R2 moves to position 7.

Hunting for an Idle Junction to Final Selector (25 and 27).

(1) Forty-eight volts *viâ* GLR, R7 of R2, F3 of R1 to earth. GLR energised, and 48 volts *viâ* power magnet PG of brush carriage, E7 of R2, contacts of GT2R and GLR to earth. PG energised and brush carriage rotates.

(2) When an idle circuit to final selector is found, 48 volts *viâ* P1 and O1 of R final, relay QR, brush G, 800^{ω} winding of GT1R, K7 of R2 to earth. GT1R energised, and then branch current *viâ* its 15^{ω} winding, N7 of R2, GINT to earth. GINT opens in the notch of the arc and earth removed, then circuit completed *viâ* relay GT2R, G7 of R2 to earth. GT2R energises and disconnects PG.

(3) Forty-eight volts *viâ* holding-magnet HG, D7 of R2, contacts of GT2R and GLR to earth. HG energises, and the brush carriage is thus held on an idle junction.

(4) Forty-eight volts *viâ* R2, its contact C7, contacts of GT2R, and GLR to earth. R2 operates and moves to position 10.

(5) Forty-eight volts *viâ* P2, M10 of R2, springs of INT2 to earth. P2 energised and trip spindle returns to its home position.

Subscriber sends 10's Digit (25 and 26).

For figure 7, six short and one long interruption will occur. These will be received by the register, at the same time as the latter is controlling the movements of the Group Selector referred to above, proceeding after item (9) "Subscriber sends 100's digit" as follows:

(1) For each short interruption SR and DR will be de-energised.

(2) After each short interruption SR will be again operated, and then 48 volts *viâ* RG10 its contact "b." J8 of R4, contacts and 14^{ω} winding of DR, contacts of MR1 and

SR to earth. RG10 will move one step after each interruption, *i.e.*, six times, from position 1 (see item 9 "Subscriber sends 100's digit") to position 7.

(3) During the long interruption similar conditions exist to those outlined in item (4) "Subscriber sends 1000's digit"; in this case R4 moves from position 8 to 11.

(4) After the long interruption SR is again operated, and *RGU moves to position 1, viâ* J11 of R4. For circuit conditions see items (6) and (7) "Subscriber sends 1000's digit."

(5) After R4 leaves position 8, Lamp 10 S is extinguished and Lamp US glows, *viâ* S9 to 15 of R4.

(6) Forty-eight volts, *viâ* R5, its contacts C7, D9 of R4 to earth. R5 operates and moves to position 8, thus completing the transmitting circuit of the register, for controlling the rotation of the final selector trip spindle.

REGISTER CONTROLS FINAL SELECTOR (**25**, **26** AND **27**).

(1) Forty-eight volts *viâ* FLR, contact M1 of R final, brush F, contact P10 of R2. H of R3, stepping relay SR1, contacts of AR, F8 of R5, K of R3, O10 of R2, I1 of R final to earth.

Relays FLR and SR1 energised and D1R disconnected.

(2) Forty-eight volts *viâ* R final, its contact D1, contacts of FLR to earth. R final operates and moves to position 2.

(3) Forty-eight volts *viâ* final selector trip spindle magnet P2, contacts E2 of R final, contacts of FLR to earth. P2 energised and trip spindle rotates.

(4) In moving from position 0 to 1, etc., the trip spindle places direct earth from its INT2 contacts (as indicated in item (3) "Register control's group selector") *viâ* N2 of R final to relay FLR, thus short-circuiting stepping relay SR1.

(5) Each time SR1 de-energises, 48 volts *viâ* RG10 its contacts "b" and "c" contact P10 of R5 contacts and 14ω winding of D1R and SR1 to earth. RG10 thus moves three steps from position 7 (see item 2, "Subscriber sends 10's digit") to position 0. The trip spindle is now in the third notch and when it reaches the fourth tooth and again short-circuits SR1, then,

(6) Forty-eight volts *viâ* in parallel R5 and relay AR, contact D8 of R5, contact "d" of RG10, P8 of R5, contacts and 14ω winding of D1R, contacts of SR1 to earth R5 is operated and moves to position 9, relay AR is also energised, thus disconnecting the circuit of SR1.

(7) When the trip spindle reaches the fourth notch FLR is also disconnected, and then P2 is released; the trip spindle is thus set to trip the brushes of the final selector brush carriage, for the fourth level, *i.e.*, subscribers' 70 to 79 of the 2200 and 2300 group as desired.

(8) Forty-eight volts *viâ* R final, its contact D2, contacts of FLR to earth. R final, operates and moves to position 3.

SUBSCRIBER SENDS UNITS DIGIT (**25** AND **26**).

For figure 2 one short and one long interruption will occur.

(1) For the short interruption, SR and DR will be de-energised.

(2) After the short interruption, SR will again operate and RGU will be stepped from position 1 to position 2, being operated *viâ* J11 of R4, etc. (See item 4, "Subscriber sends 10's digit").

(3) During the long interruption, similar conditions exist to those outlined in item 4, "Subscriber sends 1000's digit"; in this case R4 moves from position 11 to 14.

(4) Forty-eight volts *viâ* R5 its contact B9, contact E12 of R4 to earth, R5 operates and moves to position 10, thus completing the transmitting circuit of the register for controlling the rotation of the final selector brush carriage.

FINDING CALLED SUBSCRIBER'S LINE ON FINAL SELECTOR (**25**, **26**, AND **27**).

(1) Forty-eight volts *viâ* FLR, contact M3 of the R final, brush F, P10 of R2, H of

R3, stepping relay SR1, etc., to earth, as indicated in item (1) "Register controls final selector." Relays FLR and SR1 energised, and D1R disconnected.

(2) Forty-eight volts *viâ* R final, its contact D3, contacts of FLR to earth. R final operates and moves to position 4.

(3) Forty-eight volts *viâ* final selector brush carriage driving magnet P1, contact F4 of R final, contacts of FLR to earth P1 energised and brush carriage rotates.

(4) As the lever of the brush carriage moves over the terminal arc notches direct earth is placed on the INT1 contacts *viâ* N4 of R final to FLR, thus short-circuiting relay SR1.

(5) Each time SR1 de-energises, 48 volts *viâ* RGU, its contacts "b," "c," P10 of R5 contacts, and 14ω winding of D1R, contacts of SR1 to earth. RGU thus moves 8 steps from position 2 (See item 2 "Subscriber sends units' digit") to position 0. The lever of the brush carriage is now in the eighth notch, and when it rides on the crown of the ninth tooth again short-circuits SR1, then,

(6) Forty-eight volts *viâ* RGU, its contact "b," contacts of relay HTR (this relay was energised when the even hundreds digit 2 was dialled (see item 7, "Subscriber sends 100's digit"), contact "d" position 0 of RGU, P10 of R5, etc., to earth on SR1. RGU operates and commences its second revolution.

(7) When R5 passed from position 9 to 10 (see item 4, "Subscriber sends units' digit,") relay HTR remains locked *viâ* contacts "e" of RGU, which is disconnected between positions 0 and 1 only.

(8) RGU therefore makes 10 additional steps (relay HTR is now disconnected on contact "e" between positions 0 and 1 when the second revolution is made by RGU), and this time stops on its home position 0. The lever of the brush carriage is now in the eighteenth notch of the terminal arc, and when it rides on the crown of the nineteenth tooth again short-circuits SR1, then

(9) Forty-eight volts in parallel *viâ* R5 and relay AR, D10 of R5, contacts of relay HTR, contact "d" of RGU, P10 of R5, etc., to earth on SR1. R5 operates and moves, to position 12, and Lamp 10 S glows again. Relay AR is also energised, thus disconnecting the circuit of SR1.

(10) When the lever of the brush carriage reaches the nineteenth notch on the terminal arc, FLR is also disconnected and P1 released, then

(11) Forty-eight volts in parallel *viâ* holding magnet H and R final, contacts of FLR to earth. R final operates and moves from position 4 to 10, and the brushes are held on the nineteenth set of terminals on the fourth level of the 2200 and 2300 final selector, *i.e.*, opposite subscriber's line 2272 as desired.

REGISTER DISCONNECTED FROM GROUP SELECTOR AND RESTORED TO NORMAL (25 AND 26).

(1) Forty-eight volts *viâ* R1, its contacts D3, N of R3, I11 of R5, Key CCHK to earth., R1 operates and moves to position 6, disconnecting GLR between position 3 and 6.

(2) Whilst GLR is thus disconnected, 48 volts *viâ* R2, its contact C10, contacts of GLR to earth. R2 operates and moves to position 11.

(3) When R final leaves position 4, its O contact removes the short-circuit across the 4000ω winding of relay QR, and test relays GT1R and GT2R of the group selector release, then,

(4) Forty-eight volts *viâ* R2, its contact B11, contacts of GT2R and GLR to earth. R2 operates and moves to position 13, thereby connecting the calling side of the cord circuit, *viâ* its contacts O and P to the brushes of the group selector associated with the final selector. This operation also disconnects the transmitting side of the register from the group selector.

(5) Forty-eight volts *viâ* R1, its contact B6, contact I12 of R2 to earth. R1 operates and moves to position 8, thereby connecting the answering side of the cord circuit, *viâ* its contacts I and K, with the calling subscriber's loop. Supervisory relay S1R is energised and relay GLR disconnected.

(6) When R1 leaves position 5, the receiving side of the register is disconnected from the group selector, the stepping relay SR is de-energised, and the latter releases DR, then

(7) Forty-eight volts *viá* N14 of R4, relay MR, contacts of SR to earth. MR operates and disconnects relay MR1.

(8) Forty-eight volts *viá* R4, contacts of MR to earth. R4 operates and moves to position 15, disconnecting relay MR.

(9) Forty-eight volts *viá* R5, its contact D12. contact "d" of RG10, P12 of R5, H15 of R4, 14^{ω} winding of D1R, to earth on SR1. R5 operates and moves to position 14.

(10) Forty-eight volts *viá* R5, its contact D14, contacts of relay HTR "d" of RGU, P14 of R5, etc., to earth on SR1. R5 operates and moves to its home position 1.

(11) Forty-eight volts *viá* R4, its contact B15, contact H1 of R5 to earth. R4 operates and moves to its home position 1, thereby disconnecting the circuits of the supervisory lamps RGL, 10S, and US.

Testing and Ringing the Called Subscriber (**25** and **27**).

(1) R final in position 7 tests the called subscriber's line; if disengaged, the 1200^{ω} winding of test relay FT1R is energised from the 48 volts on SM and COR of the called line, *via* brush C to earth on contact G7. FT1R operates and circuit for 30^{ω} winding now completed, *via* its front contact. FT2R now energised, *via* contacts of QR to earth. Relay COR also energised, and circuit guarded from other calls in consequence of low resistance path now afforded *via* 30^{ω} of FT1R and 50^{ω} of FT2R.

(2) Forty-eight volts *via* R final, its contacts C10, contacts of FT2R and FLR to earth. R final operates and moves to position 12. The called subscriber is now rung *via* J12 of R final, brush A subscriber's line, brush B, contact L12, tripping relay RGR. 48-volt. battery to earth.

(3) When R final passes position 9 and 11, brushes E and F are looped through 600^{ω} *via* contacts I9 and K9 of R final, then circuit of calling side of cord circuit closed from 24 volt. *via* relay S2R, contacts P13 and O13 of R2. S2R operates.

(4) Forty-eight volts *via* R1, its contact B8, contacts of S2R to earth. R1 moves to position 9, and a short tone is sent over the calling subscriber's line from induction coil IC1 contacts J9 and H9 of R1, to indicate that the called subscriber is being rung.

(5) When R final passes position 11, the loop *via* brushes E and F is disconnected, and relay S2R de-energised; then, 48 volts *via* R1, its contact C9, contacts of S2R to earth. R1 moves to position 10, and disconnects the tone from the calling subscriber's line.

(6) In position 11 of R final, 48 volts *via* P2, E11 of R final, contact springs of INT2 to earth. P2 is energised, and trip spindle returns to its home position 0.

Called Subscriber replies (**25** and **27**).

(1) Forty-eight volts *viá* relay RGR, contact L12 of R final, brush B, subscriber's loop, brush A, J12 of R final to earth. RGR operates.

(2) Forty-eight volts *viá* R final, its contacts C12, contacts of RGR to earth. R final moves to position 13, and closes the circuit of the calling cord from 24 volts, *viá* relay S2R, P13 of K2, brush F, L13 of R final, brush B, subscriber's loop, brush A, J13 of R final, brush E, O13 of R2 to earth on repeating coil. Relay S2R is energised.

(3) Forty-eight volts *viá* R1, its contact B10, contacts of S2R to earth. R1 moves to position 15, and the desired connection between the two subscribers is effected.

Conversation completed (**25** and **27**).

(1) When the calling subscriber hangs up his receiver, relay S1R is de-energised; then, 48 volts *viá* release relay RR, E15 of R1, contacts of S1R to earth. RR operates and disconnects relays COR and RR1.

(2) Forty-eight volts *viá* R2 contacts of RR, J13 of R2 to earth. R2 moves to position 18.

(3) In position 14 of R2, 48 volts *viá* R1, its contacts D15, I14 of R2 to earth. R1 energised and moves to its home position 1.

(4) In position 14 to 17 of R2, and 16 to 18 of R1, the special meter battery is connected *viâ* contact Q of R2, L of R1, brush C, to the meter operating the latter.

(5) When R1 reaches position 16, GLR is operated, *viâ* R of R2 and F of R1; then, 48 volts *viâ* PG, E18 of R2, contacts of GT2R and GLR to earth. The brush carriage rotates to its home position; then,

(6) Forty-eight volts *viâ* HG, D18 of R2, home contact of GINT, N18 of R2, relay GT2R, G18 of R2 to earth. HG and relay GT2R operated, and PG disconnected.

(7) Forty-eight volts *viâ* R2, its contact C18, contacts of GT2R and GLR to earth. R2 moves to its home position 1, and GLR, HG, and GT2R are released.

Final Selector returns to Normal (**25** and **27**).

(1) Relay QR is disconnected when R2 leaves position 13, and therefore until R final reaches its home position the final selector tests engaged to other calls.

(2) Forty-eight volts *viâ* R final, its contact B13, contacts of QR to earth. R final moves to position 15.

(3) Forty-eight volts *viâ* R final, its contact D15, contacts of FLR to earth. R final passes to position 18.

(4) Forty-eight volts *viâ* P1, F18 of R final, contacts of FLR to earth. Brush carriage rotates to normal.

(5) Forty-eight volts *viâ* FLR, N18 of R final home position of INT1 to earth. FLR operated; this disconnects P1 and holding magnet H; and R final is now energised *viâ* D18 of R final, contacts of FLR to earth, and returns to its home position 1.

Called Subscriber engaged (**25** and **27**).

(1) Test relay FT1R is not energised in position 7 of R final, as its 1200^{ω} winding does not receive sufficient current from relay COR in parallel with relays FT1R (30^{ω} winding) and FT2R of the engaged circuit. R final therefore passes to position 10.

(2) Forty-eight volts *viâ* power magnet P1, contact F10 of R final, contacts of FT2R, and FLR to earth, causing brush carriage to rotate to normal position.

(3) Forty-eight volts *viâ* FLR contact, N10 of R final, home contact of INT1 to earth. FLR operated, and holding magnet H and R final energised *viâ* contacts B10 and D10 of R final.

(4) R final passes to position 11, and the 600^{ω} loop is placed across the calling cord, causing a tone to be sent to the originating subscriber. (See item 3 "Testing and ringing the called subscriber.") In this case, however, the tone continues until the calling subscriber restores his receiver and the selectors are released.

Disconnection without Metering (**25**).

(1) When contacts O16 and 17 of R2 are made at the same time as contacts L16 to 18 of R1, the meter operates (see item 4 "Conversation completed").

(2) This occurs after the completion of a successful call only, as in the event of the calling subscriber replacing his receiver before the called subscriber answers, release relay RR is energised, *viâ* contact E10 of R1, and contact S1R to earth.

(3) This operation disconnects relays RR1 and COR, and energises R2 *viâ* contacts of RR, and J13 of R2 to earth. R2 moves from position 13 to 18.

(4) In position 14 of R2, R1 is energised *viâ* its contacts D10, I14 of R2 to earth. R2 will therefore pass position 17 before R1 can reach position 16.

Restoration of Switches to Normal under Abnormal Conditions.

Premature disconnections by originating subscribers may occur at any stage during the progress of a call.

FIRST CASE (25).

Assume that the calling subscriber restores his telephone before commencing to dial, say after item (3) "Free line finder reaches calling subscriber's line," *i. c.*, before R2 reaches position 3.

(1) Relays GT1R and GT2R released; GLR remains operated *viá* R of R2 and F of R1; then 48 volts *viá* release relay RR, F2 of R2, contacts of GT2R, and GLR to earth. COR is therefore not operated, and the subscriber's line is free to make another call.

(2) When R2 reaches position 3, it will remain so until an idle register is found; then R2 moves to position 5 (see item 4, "Finding a free register").

(3) Forty-eight volts *viá* R1, its contact B1, I3 of R2 to earth. R1 moves to position 2.

(4) If an idle register is not found; when R3 reaches position 13, 48 volts *viá* R2, contacts of RR (locked *viá* its contacts when R2 moved from position 2 to 3) J3 of R2, B13 of R3 to earth. R2 operates and moves to position 5.

(5) Forty-eight volts *viá* R1, its contact D2, I5 of R2 to earth. R1 moves to position 3.

(6) Forty-eight volts *viá* R2, contacts of RR, J5 to 8 of R2, to earth. R2 moves to position 9.

(7) Forty-eight volts *viá* HG, D9 of R2, home contact of GINT, N9 of R2 relay GT2R, G9 of R2 to earth. GT2R energised.

(8) Forty-eight volts *viá* R2, its contact C9, contacts of GT2R, and GLR to earth. R2 moves to position 10, disconnecting GT2R.

(9) Forty-eight volts *viá* R2, contacts of relay RR, J10 to 13 of R2 to earth. R2 operates and moves to position 18.

(10) Forty-eight volts *viá* R1, its contact B3, I12 of R2 to earth. R1 moves to position 6.

(11) Forty-eight volts *viá* R1, its contact D6, etc., I14, etc., of R2 to earth. R1 moves to position 1.

(12) Forty-eight volts *viá* HG, D18 of R2, home contact of GINT, N18 of R2, relay GT2R, G18 of R2 to earth. GT2R energised; then,

(13) Forty-eight volts *viá* R2, its contacts C18, contacts of GT2R, and GLR to earth. R2 moves to position 1 and releases GT2R and GLR.

SECOND CASE (**25** AND **26**).

(1) Assume that the subscriber disconnects after the register has been connected and that RG1000 stepped off normal; then stepping relay SR released and MR operates, stepping R4 to position 15.

(2) Forty-eight volts *viá* R5, its contact C1, D of R4 to earth. R5 moves to position 4 and then to 6 *viá* C of R4.

(3) Forty-eight volts *viá* RG 1000, its contacts "b" and "c," contact "d" of RG 100, O6 of R5, H15 of R4, 14" winding of D1R, to earth on SR1.

(4) Forty-eight volts in parallel *viá* AR and R5, "d" of RG 1000, K of R5, "d" of RG 100, O6 of R5, etc., to earth on SR1. R5 operates and moves to position 8, and then to position 1, *viá* "d" contacts of RG10, and RGU in a similar manner.

(5) Forty-eight volts *viá* R4, its contacts B15, H1 of R5, to earth. R4 operates and moves to position 1, thus completing the restoration of the register.

(6) The group selector is restored by 48 volts *viá* R1, its contact D3, N of R3, G15 of R4, I of R5 to earth *viá* key CCHK. R1 moves to position 6.

(7) Forty-eight volts *viá* release relay RR, E5 of R1, N of R3, etc., to earth. RR operates and energises R2, which moves to position 9, and the restoration of R1 and R2 then follows as indicated in (7), etc., for the first case of premature disconnection.

THIRD CASE (25, 26 AND 27).

(1) Assume that the subscriber disconnects whilst the group selector is finding an idle junction to final selector; the restoration will be similar to the second case, but R2 cannot move from position 9 until the brush carriage returns to its home position; then R1 and R2 stepped back to normal as in first case (7), etc.

(2) If the brush carriage finds an idle junction before reaching its home position; then GT2R energised (see item 2 " Hunting for idle junction to final selector ") and R2 and R1 now restored as in first case (8), etc.

(3) Brush carriage restored to normal by 48 volts *viâ* PG, E18 of R2, contacts of GT2R, and GLR to earth.

FOURTH CASE (25 AND 27).

(1) Assume that the subscriber restores his telephone whilst the register is controlling the trip spindle of the final selector. R final is in position 3 when the selection of the level is completed, and remains there until R2 passes position 13 (group selector restored as in third case), when relay QR of final selector will be de-energised; then—

(2) Forty-eight volts *viâ* R final, its B contact, contacts of QR to earth. R final operates and moves to position 4.

(3) Forty-eight volts *viâ* R final, its D contact, contacts of FLR to earth. R final moves to position 10.

(4) Forty-eight volts *viâ* P1, F10 of R final, contacts of FT2R, and FLR to earth. P1 energised and brush carriage returns to home position.

(5) Forty-eight volts *viâ* FLR, N10 of R final, home contact of brush carriage interrupter springs INT1 to earth. FLR energised.

(6) Forty-eight volts *viâ* R final, its contact D10, contacts of FLR to earth. R final moves to position 11 and disconnects FLR.

(7) Forty-eight volts *viâ* R final, its B contact, contact of QR to earth. R final moves to position 15.

(8) Forty-eight volts *viâ* R final, its contact D15, contacts of FLR to earth. R final moves to position 18.

(9) Forty-eight volts *viâ* FLR, N18 of R final, home contacts of INT1 springs to earth. FLR energised.

(10) Forty-eight volts *viâ* R final, its contact D18, contacts of FLR to earth. R final moves to position 1, and disconnects FLR, thus leaving R final free for another call.

FIFTH CASE (25 AND 27).

(1) Assume that the subscriber disconnects after dialling whilst the final selector brush carriage is passing to the called line. QR of final selector will be de-energised as in fourth case: in position 7 of R final, test relays FT1R and FT2R will not therefore operate.

(2) When R final reaches position 10, the release of the switches will be similar to fourth case.

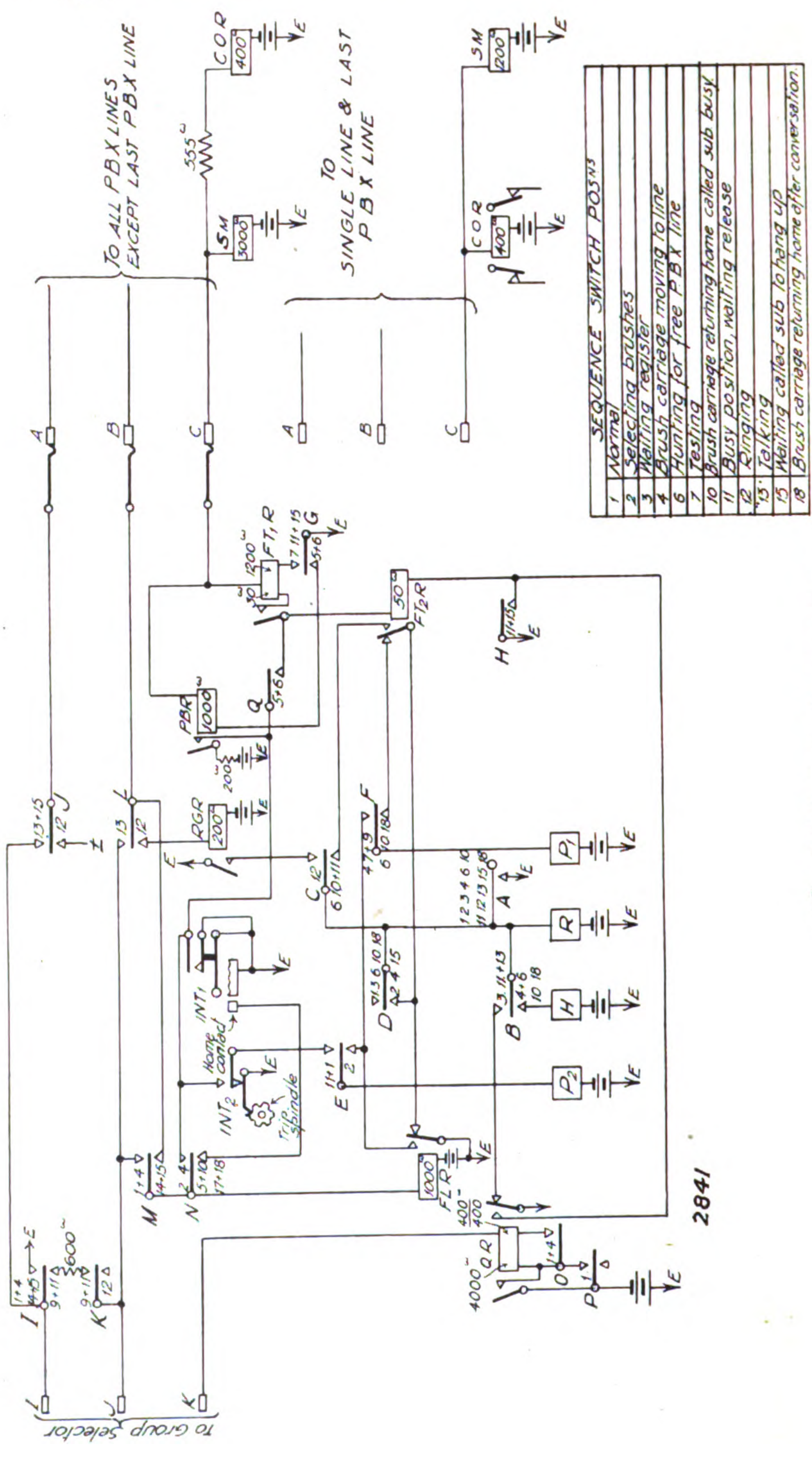
PRIVATE BRANCH EXCHANGE LINES (28).

For this service an additional relay PBR is provided in each of the final selector circuits of one of the 200-line units.

All subscribers' circuits in a group of P.B.X. lines, except the last circuit, are wired with a resistance of 555$^{\omega}$ in series with the cut-off relay.

The subscribers' equipment of the last P.B.X. line is joined up as an ordinary direct single subscriber.

These modifications enable relay PBR to discriminate, it will


TO ALL PBX LINES EXCEPT LAST PBX LINE
TO SINGLE LINE & LAST PBX LINE
To Group Selector
COR 400
SM 3000
555ω
SM 200
COR 400
SEQUENCE SWITCH POSNS
1 Normal
2 Selecting brushes
3 Waiting register
4 Brush carriage moving to line
6 Hunting for free P.B.X line
7 Testing
10 Brush carriage returning home called sub busy
11 Busy position, waiting release
12 Ringing
13 Talking
15 Waiting called sub to hang up
18 Brush carriage returning home after conversation
A
B
C
FT1R 1200ω
FT2R 50
PBR 1000
RGR 200
QR 4000
FLR 1000
G
H
Q
I
J
K
L
M
N
O
P
D
E
F
INT1
INT2
Home contact
Trip spindle
P1
P2
R
H
600ω
2841

28.—P.B.X. FINAL SELECTOR CIRCUIT.

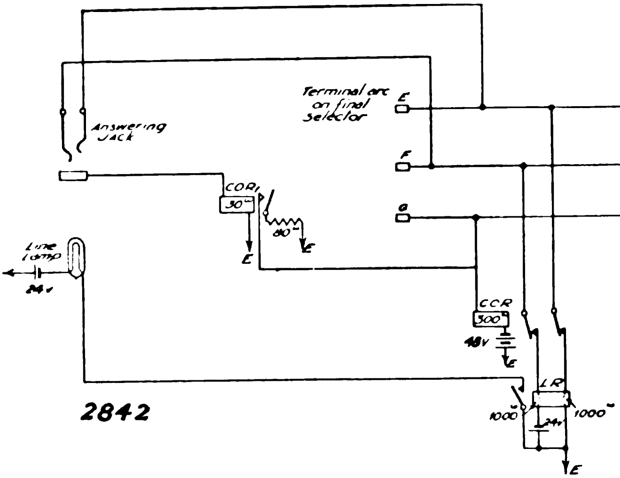
operate whether the *last* P.B.X. line is engaged or not, and the final selector then operates precisely similar to that previously described. Relay PBR will not operate, however, unless one of the lines in the P.B X. group reached before the *last* one is disengaged.

Sequence switch R final comes to rest in position 6, *i.e.*, hunting for free P.B.X. line, and the following operations are effected :

(1) Forty-eight volts *viâ* P1, F6 of R final, contacts of relay FT2R, and FLR to earth. P1 is energised and brush carriage rotates.

(2) When a disengaged line in the P.B.X. group is found, or when the *last* circuit in the P.B.X. group is reached, PBR receives sufficient current to operate from 48 volts *viâ* COR and SM brush C, relay PBR, contact G of R final to earth.

(3) Forty-eight volts *viâ* 200ω spool, contacts of relay PBR, Q6 of R final, relay FT2R, contacts of relay QR to earth. FT2R operated.



29.—Coin-Box Subscriber's Circuit.

(4) Forty-eight volts *viâ* R final, its contact C6, contacts of relay FT2R, and FLR to earth. R final passes to position 7.

(5) If subscriber's line disengaged, test relay FT1R operated, and the connection proceeds as previously explained under "Testing and Ringing the Called Subscriber."

(6) If subscriber's line engaged, relay FT1R is not energised, and R final passes to position 10. The connection proceeds as previously explained under "Called Subscriber Engaged."

Coin Box Circuits (29).

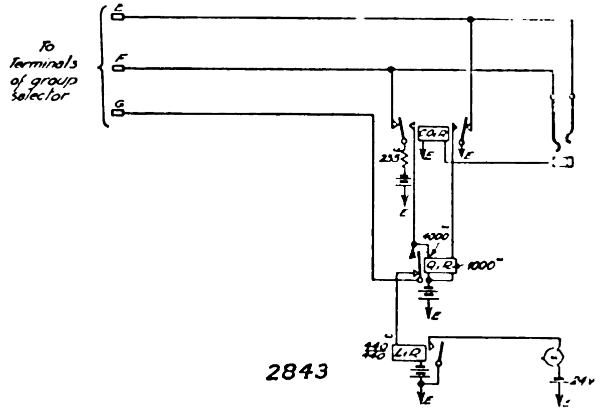
Calls originated by a coin box subscriber energise the 1000 + 1000^{ω} relay, and the calling lamp glows. When the operator answers, the call proceeds on similar lines to those for a standard C.B. manual exchange. The 30^{ω} cut-off relay is operated and this energises the 300^{ω} cut-off relay, which de-energises the line relay and extinguishes the calling lamp. In addition it causes the sleeve wire on the final selector to test engaged to other subscribers, as the

1200^{ω} winding of test relays FT1R of the final selector (**27**) does not receive sufficient current from the 48 volts, *viâ* the 300^{ω} cut-off relays in parallel with the 80^{ω} circuit completed *viâ* the 30^{ω} cut-off relay.

This scheme, therefore, enables all incoming calls for coin box subscribers to be dealt with automatically, and for all calls originated by coin box subscribers to reach the manual board operator, in order that insertion of coins may be supervised. Cross-connection facilities are available so that any automatic subscriber's number may be converted to coin box working in the above manner.

AUTOMATIC SUBSCRIBERS CALLING MANUAL BOARD OPERATOR, (25, 26 and 30).

(1) The operation of the circuits for "trunk record" (12 dialled), enquiry (14 dialled), and "party-line subscriber" (18 etc. dialled), are similar. In each case the 1000's register RG 1000 is in position 2, *i.e.*, digit 1 has been dialled first.



30.—JUNCTION CIRCUIT INCOMING TO THE MANUAL BOARD, FROM AUTOMATIC PLANT.

(2) When sequence switch R5 is passing position 2—which happens immediately after the 1000's digit has been dialled (see item 9 under "Subscriber sends 1000's digit") —48 volts *viâ* relay TRR, contact Q2 of R5, "g"2 of RG 1000 to earth. Relay TRR operated, and remains locked *viâ* its armature and contacts H2 to 12 of R5.

(3) Assume the subscriber wishes to make a trunk call; 12 is dialled. RG 1000 will be in position 2, and RG 100 in position 4. It will be seen from the schedule that the ninth level of the group selector will be found in a similar manner to that explained under "Register Controls Group Selector." It will be observed in item 7 that after RG 1000 and RG 100 are stepped back to their home position, R5 moves to position 7; then,

(4) As TRR is energised, 48 volts *viâ* R5, contacts TRR, L7 of R5 to earth. R5 operates and moves to position 8, thus completing the circuit to enable the group selector to hunt for an idle line circuit to the manual board as follows:

(5) Forty-eight volts *viâ* relay L1R, contacts of relay Q1R, brush G, 800^{ω} winding of relay GT1R, contact K7 of R2 to earth. L1R energised and calling lamp on manual

board glows. Relay GT1R also energised, and *viá* its 15^{ω} winding relay GT2R is operated *viá* contact G7 of R2.

(6) Forty-eight volts *viá* R2, its contact C7, contacts of relay GT2R, and GLR to earth. R2 operated and passes to position 10.

(7) Forty-eight volts *viá* 235^{ω} resistance, contacts of relay COR, brush F, contact P10 of R2, contact H of R3, relay SR1, contacts of relay AR, contacts F8 of R5, K of R3, O of R2, brush E, contacts of COR to earth. Stepping relay SR1 energised.

(8) Forty-eight volts *viá* R5, contacts of relay TRR, L8 of R5, 15^{ω} winding of relay AR, contacts of SR1, to earth. R5 operated and passes to position 9, disconnecting SR1, and the transmitting side of the register. Relay AR1 is not energised, as its 1000^{ω} winding acts in opposition to the 15^{ω} winding, *viá* a circuit in parallel with that traversed by R5.

(9) Forty-eight volts *viá* R5, contacts of relay TRR, contact L9 of R5 to earth. R5 operated and passes to position 12.

(10) When R5 passes position 11, 48 volts *viá* R1, its contact D3, N of R3, contact I11 of R5 to earth. R1 operates and passes to position 6. This disconnects SR and the receiving side of the register at J5 of R1, and R2 moves to position 11, being energised *viá* its contact C10 and GLR, when R1 leaves position 3.

(11) When SR de-energises, 48 volts *viá* N of R2, relay MR, contacts of SR to earth. Relay MR operated.

(12) Forty-eight volts *viá* R4, contacts of MR to earth, R4 operated and passes to position 15.

(13) RG10 is restored to normal *viá* P12 of R5, H15 of R4, 14^{ω} winding of D1R to earth on SR1; then,

(14) Forty-eight volts in parallel *viá* AR and R5, *viá* D15 of R5, "d" contact of RG 10, P12 of R5, etc. R5 moves to position 14, and so enables RGU to be restored to normal in a similar manner to RG10. Then R5 returns to position 1.

(15) Forty-eight volts *viá* R4, its contact B15, contact H1 of R5 to earth. R4 operated and passes to position 1.

(16) The subscriber is now connected direct with the jack on the manual board, *via* ring spring of jack, brush F of group selector, contact K6 of R1, contacts of relay RR1, brush B of line finder, subscriber's loop, brush A of line finder, contacts of relay RR1, contact I6 of R1, brush E of group selector, and tip spring of jack.

(17) When the operator answers, relays COR and QR are operated, and relay L1R and calling lamp disconnected. Forty-eight volts in parallel *viá* 235^{ω} resistance and 4000^{ω} winding of relay Q1R to brush G, *via* test relays GT1R and GT2R to earth, maintaining sequence switch R2 in position 11; otherwise the group selector cord circuit would not be isolated from this connection.

(18) The subscriber is now fed with talking current from the manual board cord circuit, **thus affording the maximum efficiency from a transmission standpoint.**

(19) The release of the subscriber can be effected by the withdrawal of the plug by the operator only, *i.e.*, when the supervisory clearing signal is received, as follows:

(20) Relay COR de-energised; relay Q1R remains operated *viá* its 4000^{ω} winding, its contacts, brush G, relay GT1R 800^{ω} winding, contact K11 to earth. Test relays GT1R and GR2R de-energise, as they do not receive sufficient current *viá* 4000^{ω} winding of relay Q1R.

(21) Forty-eight volts *viá* R2, its contact B, contacts of GT2R and GLR to earth. R2 moves to position 13.

(22) Forty-eight volts *viá* R1, its contact B6, and I12 of R2 to earth. R1 moves to position 8.

(23) Forty-eight volts *viá* release relay RR, E8 of R1, contacts of S1R to earth.

(24) Forty-eight volts *viá* R2, contacts of RR, J13 of R2 to earth. R2 moves to position 18, and release of group selector is effected without metering as previously described.

(25) In position 14 of R2, relay Q1R is disconnected, and the line relay is again connected to terminal G to receive another call.

JUNCTIONS OUTGOING FROM MANUAL BOARD TO AUTOMATIC PLANT (26, 27, and 31).

Special group selectors associated with jacks and lamp engaged signals in the outgoing junction multiple are provided for completing all calls from distant, trunk, and local exchanges, incoming to the manual boards for automatic subscribers. These outgoing junctions make use of the same registers and final selectors as those utilised by the ordinary group selectors for calls between two automatic subscribers. The *special* group selectors are wired in such a manner that *when the conversation is in progress the whole of the apparatus in the automatic plant is cut out of the transmission circuit, i.e.*, there is only one cord circuit in use, viz., that on the manual board.

(1) Operator at manual board inserts calling-plug of any cord circuit into disengaged multiple jack.

(2) Twenty-four volts *viâ* 200^ω relay in sleeve of cord circuit, bush of jack, relay RR2 of group selector to earth. Both relays energised.

(3) Forty-eight volts *viâ* relay GLR, contact S1 of R2, A line of junction circuit, to earth *viâ* supervisory relay of cord circuit. Relay GLR energised.

(4) Forty-eight volts *viâ* R2, C1 of R2 to earth *viâ* GLR. R2 energised and moves to position 3. Lamp engaged signal associated with junction jack glows, *viâ* F3 of R2, and relay GLR de-energised.

(5) Forty-eight volts *viâ* R3, contact E3 of R2, contacts of relay GT2R, and GLR to earth. R3 rotates and hunts for a free register circuit, as already described for local connections.

(6) When free register found, 48 volts *viâ* contacts P1, K1, and S1 of register set, contact E of R3, L3 of R2, GT1R relay 800 winding, contact B of R3 to earth. Relay GT1R energised, and then also relay GT2R *viâ* contact G of R2, and R3 disconnected.

(7) Forty-eight volts *viâ* R2, its contacts C, contacts of relay GT2R and GLR to earth. R2 moves to position 5.

(8) Second 30^ω winding of relay RR2 energised *viâ* I of R2, E of R3, and S of register set.

(9) Stepping relay SR of register connected *viâ* Q of R3, N of R2 to junction; and the register circuit is set by the impulses from the operator's dial similar to an auto to auto call.

(10) When the stepping relay SR1 selects the hundreds, *i.e.*, position 6 of R5 (register set), 48 volts *viâ* GLR, R5 of R2, H of R3, stepping relay SR1, contacts of relay AR, and F6 of R5 to earth. GLR and SR1 energised.

(11) Forty-eight volts *viâ* R2, its contact C5, and contact of GLR to earth. R2 moves to position 6.

(12) Forty-eight volts *viâ* P2, M6 of R2, contacts of relay GLR to earth. P2 energised and trip spindle starts to rotate, thus providing the earth connection, *viâ* INT2 and S6 of R2, to short-circuit stepping relay SR1.

(13) After RG 100 and RG 1000 restored to normal, the setting of the trip spindle to unlatch the brushes for the correct level is completed, as relay GLR is disconnected as previously explained.

(14) Forty-eight volts *viâ* R2, its contact B6, contacts of relay GT2R and GLR to earth. R2 moves to position 7.

(15) Forty-eight volts *viâ* P1, E7 of R2, contacts of relay GT2R and GLR to earth. P1 energised and brush carriage rotates. The correct brush is unlatched by the trip spindle, and then the trunks to final selectors are tested.

(16) When a free final selector is found, test relays GT1R and GT2R are energised.

as previously described for auto to auto calls; then 48 volts *viá* R2, its contact C7, contacts of relay GT2R, and GLR to earth. R2 moves to position 10.

(17) Stepping relay SR1 of register now associated with final selector, and the trip spindle and brush carriage are controlled as previously described for auto to auto calls, under "Register controls final selector."

(18) When R5 of register returns to normal, 48 volts *viá* R2, its contact B10, N of R3, and I11 of R5 to earth. R2 moves to position 11.

(19) When called subscriber found by final selector, final R moves from position 4 to 11. In position 9, 48 volts *viá* relay GLR, P11 of R2, brush F, K9 of R final, 600^{ω} resistance. I9 of R final, brush E, contact O11 of R2 to earth. GLR energised.

(20) Forty-eight volts *viá* R2, its contact C11, and relay GLR to earth. R2 moves to position 12.

(21) If called subscriber engaged; R final remains in position 11 and R2 in position 12. Interrupted battery FL then *viá* N12 of R2, tip of jack to supervisory relay and earth, thus flashing the supervisory lamp of the operator's cord circuit in the standard manner.

(22) If called subscriber free, R final passes to position 12; 600ω bridge on contacts I and K of final thus disconnected, and relay GLR de-energised. Then 48 volts *viá* R2, its contact B12, contacts of relay GT2R and GLR to earth. R2 moves to position 13, thus connecting the jack in the outgoing junction multiple direct with the final selector.

(23) R final passes to position 13 when the subscriber answers, and the called subscriber is now fed with talking battery direct from the manual switchboard, and the release of the automatic switches is entirely dependent upon the operator withdrawing the plug.

(24) When plug withdrawn, relay RR2 disconnected, and 48 volts *viá* R2, contacts of relay RR2, J of R2 to earth. R2 moves to position 18.

(25) Forty-eight volts *viá* P1, E18 of R2, contacts of GT2R and GLR to earth. P1 energised, and brush carriage returns to the home position.

(26) Forty-eight volts *viá* Holding magnet H, D18 of R2, home contact of brush carriage, relay GT2R, G18 of R2 to earth. Relay GT2R energised and P1 disconnected.

(27) Forty-eight volts *viá* R2, its contact C18, contacts of GT2R and GLR to earth. R2 moves to position 1, and lamp engaged signal associated with jack in outgoing junction multiple extinguished.

(28) R final is restored to normal as already described.

RESTORATION OF SWITCHES TO NORMAL UNDER ABNORMAL OPERATING CONDITIONS AT THE MANUAL BOARD.

FIRST CASE.—(1) Assume that the operator withdraws the plug before dialling, and when the group selector has not reached a free register set. RR2 is de-energised, and R2 remains in position 3 until a free register is found. Then R2 moves to position 5. See items (6) and (7) "Junctions outgoing from manual board to automatic plant."

(2) Forty-eight volts *viá* R2, contacts of RR2, J5 etc., of R2 to earth. R2 moves to position 9.

(3) Forty-eight volts *viá* H, D9 of R2, home contact of INT1, relay GT2R G9 of R2 to earth. GT2R energised.

(4) Forty-eight volts *viá* R2, its contact C9, contacts of GT2R and GLR to earth. R2 moves to position 10.

(5) Forty-eight volts *viá* R2, contacts of RR2, and J10 etc. of R2 to earth. R2 moves to 18.

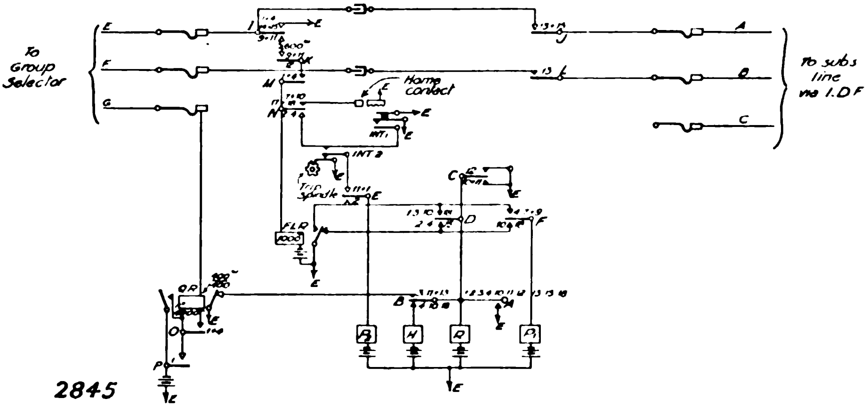
(6) In position 18, GT2R again energised as in 3; and then 48 volts *viá* R2, its contact C18, contacts of GT2R and GLR to earth. R2 moves to its home position 1, and disconnects GT2R.

SECOND CASE.—(1) Assume the operator withdraws the plug after the register is connected. Relay RR2 remains energised by 48 volts from register *viá* S of R5, E of R3, I5 of R2, winding and contacts of RR2 to earth.

(2) Stepping relay SR de-energised, releases the register as previously explained; then when R5 passes position 10, RR2 disconnected, and group selector restored as in first case.

TRUNK-OFFERING AND NUMBER-CHALLENGING CIRCUIT (32).

When an operator dials a subscriber required for a trunk conversation and receives the engaged signal, facilities are afforded to enable the operator to offer the trunk call to the wanted subscriber. Two outgoing junction jacks with visual engaged signals have been set aside for this purpose. The operator is required to withdraw the calling plug from the ordinary outgoing junction to auto, insert into one of the special trunk-offering jacks, and again dial the full number of the wanted subscriber. The selection of the wanted line is similar to that for an ordinary call. These special trunk-offering jacks are associated with group selectors similarly equipped to those used for calls between two automatic subscribers, but the levels of these group selectors are associated with special trunk-offering final selectors, one for each 200-line final unit, instead of the usual junctions to the subscribers' final selectors.



32.—TRUNK OFFERING AND NUMBER CHALLENGING FINAL SELECTOR CIRCUIT.

In the final selectors for these trunk-offering circuits, the circuits of the two test relays FT1R and FT2R, and the ringing relay RGR, are omitted, but in other respects, they are similar to subscribers' final selectors (27). This alteration enables the operator to tap in on the subscribers' line and offer the trunk call. If the trunk call is accepted, the subscribers will be asked to hang up their receivers. The operator will then withdraw the plug from the trunk-offering jack, and again call the wanted subscribers, *viâ* an ordinary outgoing junction to auto, in the usual way. The circuit also enables an operator to tap in and challenge the number of an automatic subscriber in the case of a "no-delay" junction call.

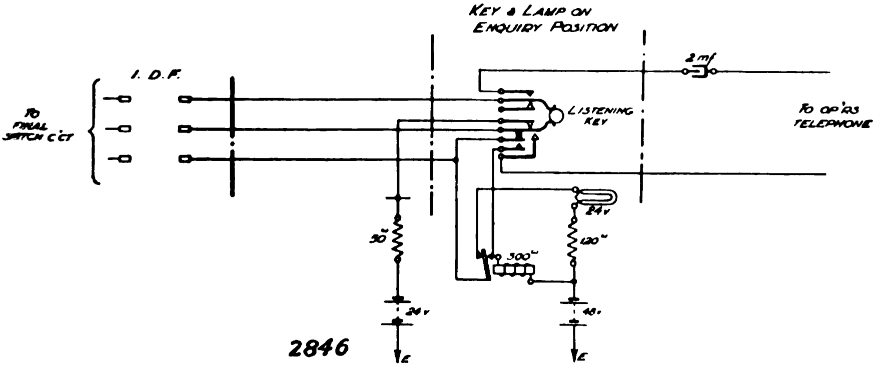
DEAD NUMBER CIRCUIT (27 AND 33).

Lines which have been given up recently, or disconnected for any cause, are associated with keys and lamps on the enquiry position, and when a subscriber dials one of the numbers concerned, the attention of the enquiry operator is obtained.

The electrical operations are precisely similar to those outlined between two automatic subscribers, but when the final selector and sequence switch R final is passing from position 4 to 10, it tests the called line in position 7, and then—

(1) Forty-eight volts *viá* 120^{ω} resistance, 24 volt calling lamp, contacts of 300^{ω} relay brush C, test relays FT1R, etc., to earth. Calling lamp glows and FT1R and FT2R energised.

(2) When position 10 is reached—48 volts *viá* R final, its contact C10 contacts of FT2R and FLR to earth. R final moves to the ringing position 12.



33.—DEAD NUMBER CIRCUIT.

(3) Forty-eight volts *viá* tripping relay RGR, L12 of R final, brush B, contacts of 300^{ω} relay, 50^{ω} resistance, 24 volt battery to earth. RGR operates.

(4) Forty-eight volts *viá* R final, its contacts C12, contacts of RGR to earth. R final operates and moves to talking position number 13.

(5) The 24-volt battery *viá* supervisory relay S2R of the group selector cord circuit is now opposed by the 24 volts, *viá* the 50^{ω} resistance on the dead number circuit, and relay S2R is, therefore, not energised. This condition also exists when the enquiry operator answers, owing to the presence of the condensers in circuit. Sequence switch R1 thus remains in position 10 and R2 is in position 13.

(6) The operator gives the necessary information, and when the calling subscriber restores his receiver RR operates, and R2 is then energised and passes to position 18.

(7) The call is not metered as—

When R2 is on position 14 R1 passes to 11 *viá* I of R2
„ R2 „ „ 15 R1 „ 12 „ I „ R2
„ R2 „ „ 16 R1 „ 13 „ I „ R2
„ R2 „ „ 17 R1 „ 14 „ I „ R2
„ R2 „ „ 18 R1 „ 15 „ I „ R2

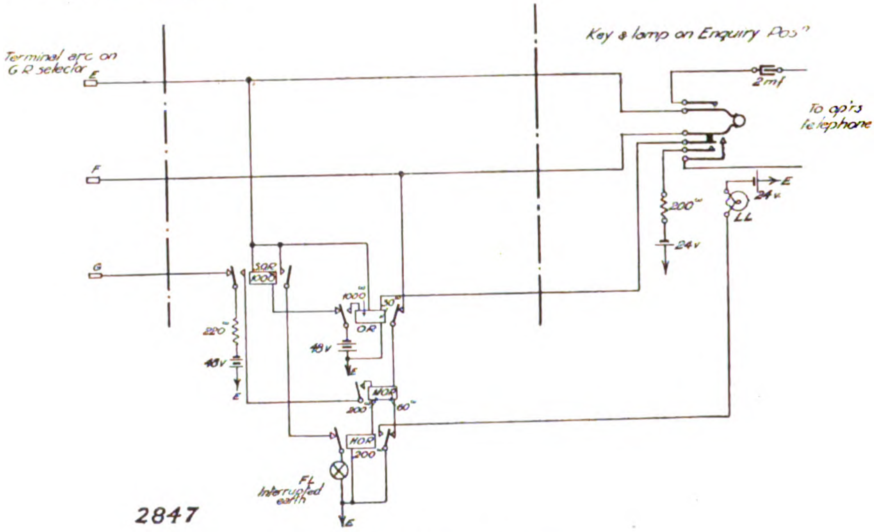
R2 passes the metering positions 14 to 17 before R1 reaches the metering positions 16 to 18.

DEAD-LEVEL CIRCUIT (25, 26 AND 34).

When a subscriber dials a wrong number, which selects a dead level on the group selector, *e.g.*, 2800–2999 on the second level, in the Darlington equipment, his line is connected direct to the enquiry operator's position as follows :

(1) 48 volts *viâ* 220ω resistance, contacts of SOR, brush G, test relays GT1R and GT2R, etc., to earth. These relays operate, brush carriage of group selectors stops, and R2 moves to position 10. The operations up to this stage are similar to those for an auto to auto call, up to "Hunting for idle junction to final selector"; then,

(2) Forty-eight volts *viâ* SOR, brush E, O10 of R2, K of R3, F8 of R5, contacts of AR, relay SR1, H of R3, P10 of R2, brush F, contact of OR, 60ω winding of MOR, contacts of HOR to earth. SOR, and SR1 operates, but not MOR, and test relays GT1R and GT2R de-energise.



34.—DEAD LEVEL CIRCUIT.

(3) Interrupted earth from FL short-circuits SR1, and so steps RG10 back to normal, then R5 moves to position 9 and SOR is released.

(4) After the units' impulses are received R4 moves to 14 and R5 to 10, as previously indicated, and then SOR is again operated *viâ* path referred to in item 2, and interrupted earth from FL enables RGU to be stepped back to normal. Then R5 moves to position 12 and releases SOR and SR1.

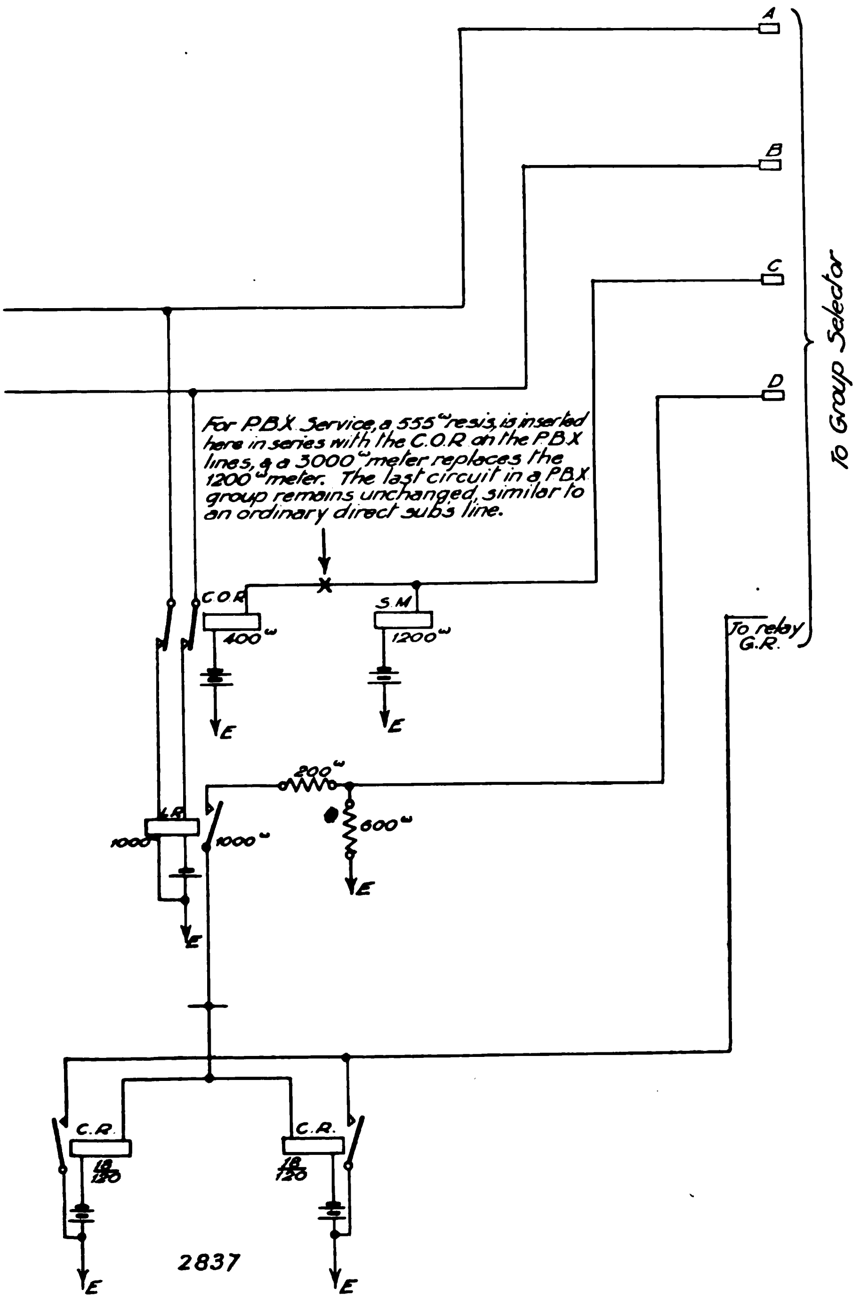
(5) Forty-eight volts *viâ* R1, its contact D3, N of R3, I11 of R5 to earth. R1 operates and moves to position 6. GLR de-energises and R2 moves to position 11, after R1 passes position 3.

(6) In position 6 of R1, GLR again operates and R2 moves to position 13.

(7) Forty-eight volts *viâ* R1, its contact E6, I12 of R2 to earth. R1 operates and moves to position 8.

(8) In position 13 of R2, the cord circuit of the group selector is connected to SOR and MOR. Relays SOR, MOR, and S2R of the cord circuit operate. The latter enables R1 to move to position 9.

(9) MOR in operating energises HOR from 48 volts *viâ* contacts of SOR, MOR, winding of MOR and HOR to earth, thus disconnecting FL and lighting the calling lamp.


For P.B.X. Service, a 555ω resis. is inserted here in series with the C.O.R. on the P.B.X lines, & a 3000ω meter replaces the 1200ω meter. The last circuit in a P.B.X group remains unchanged, similar to an ordinary direct subs line.

24.—Subscriber's Line Circuit.

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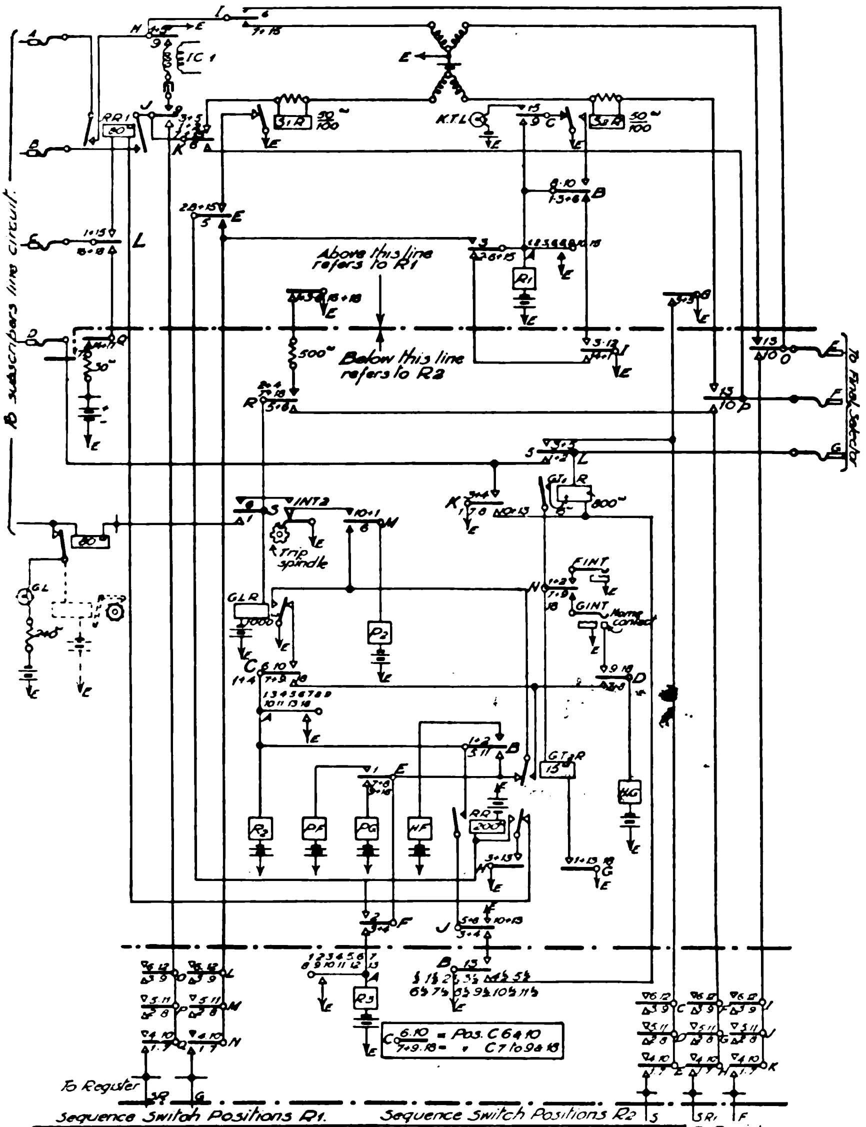

Sequence Switch Positions R1.

1	Normal
2	Waiting Register
3	Register connected
6	Register discon., waiting for R2 to pass 12
	Talking (for connections to operators pos
8	Waiting for final R to pass 9
9	Busy position, waiting release
10	Ringing
15	Talking (for local connections)
16	Metering (passing contacts)
17	" " "
18	" " "

Sequence Switch Positions R2

1	Normal
2	Hunting register
3	Waiting for R1 to move to 6
6	Selecting brushes
7	Hunting trunk
10	Waiting for R1 to move from 3
11	Talking for connections to opr's pos.
13	Talking (local connection)
14	Metering (Passing contacts)
15	" " "
16	" " "
17	" " "
18	Brush carriage returning
	Home after conversation

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25.—LINE FINDER AND GROUP SELECTOR CIRCUIT.

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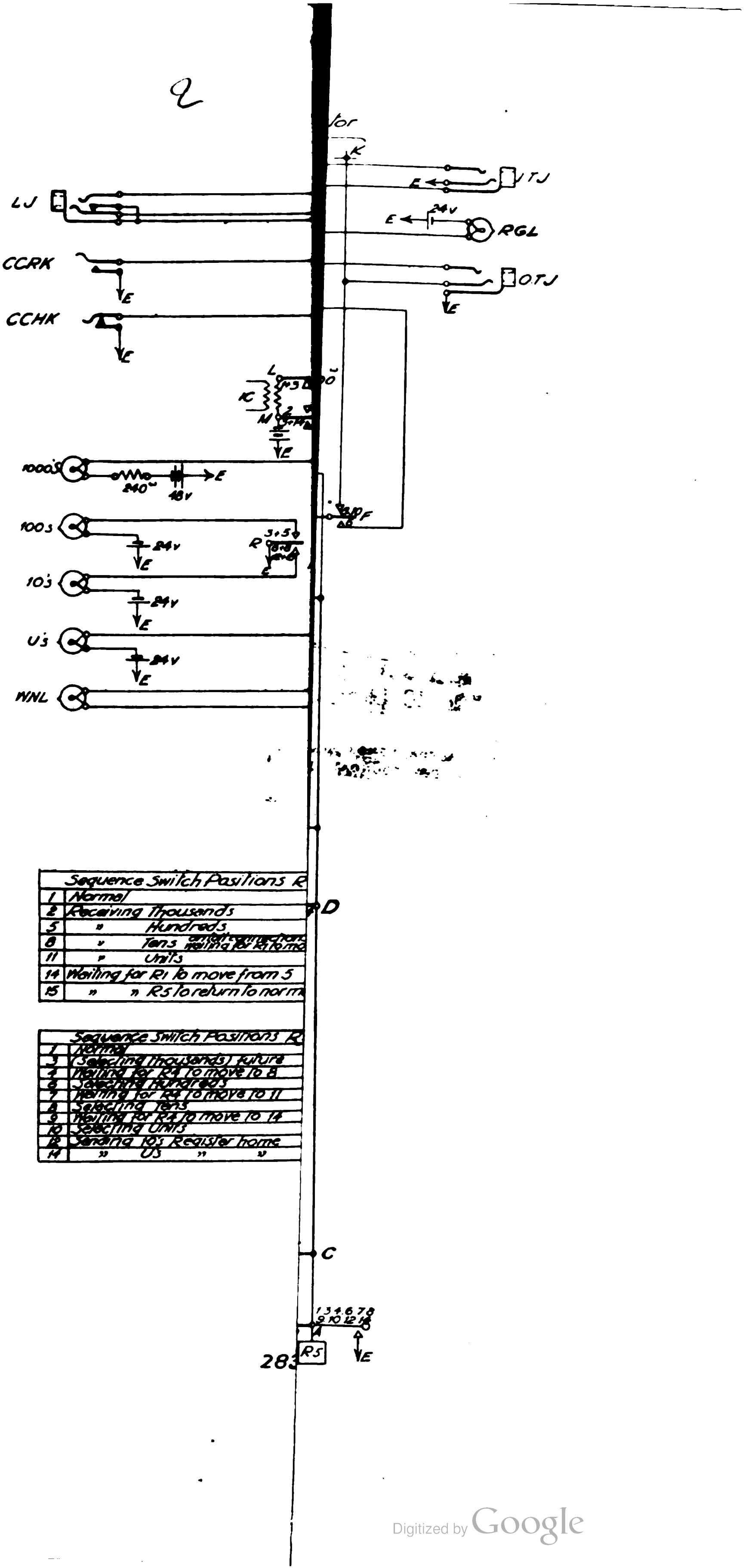
2



Sequence Switch Positions R	
1	Normal
2	Receiving Thousands
5	" Hundreds
8	" Tens and after connection waiting for R1 to m
11	" Units
14	Waiting for R1 to move from 5
15	" " R5 to return to norm

Sequence Switch Positions R	
1	Normal
3	(Selecting thousands) future
4	Waiting for R4 to move to 8
6	Selecting Hundreds
7	Waiting for R4 to move to 11
8	Selecting Tens
9	Waiting for R4 to move to 14
10	Selecting Units
12	Sending 10's Register home
14	" U's " "

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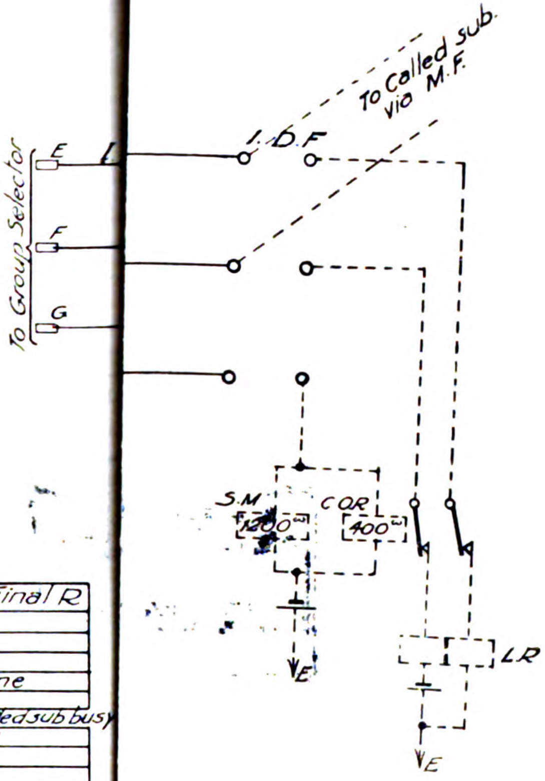
3



Sequence switch positions Final R	
1	Normal
2	Selecting Brushes
3	Waiting register
4	Brush carriage moving to line
7	Testing
10	Brush carriage returning home, called sub busy
11	Busy position waiting release
12	Ringing
13	Talking
15	Waiting called sub. to hang up
6	Brush carriage returng home after convers'n

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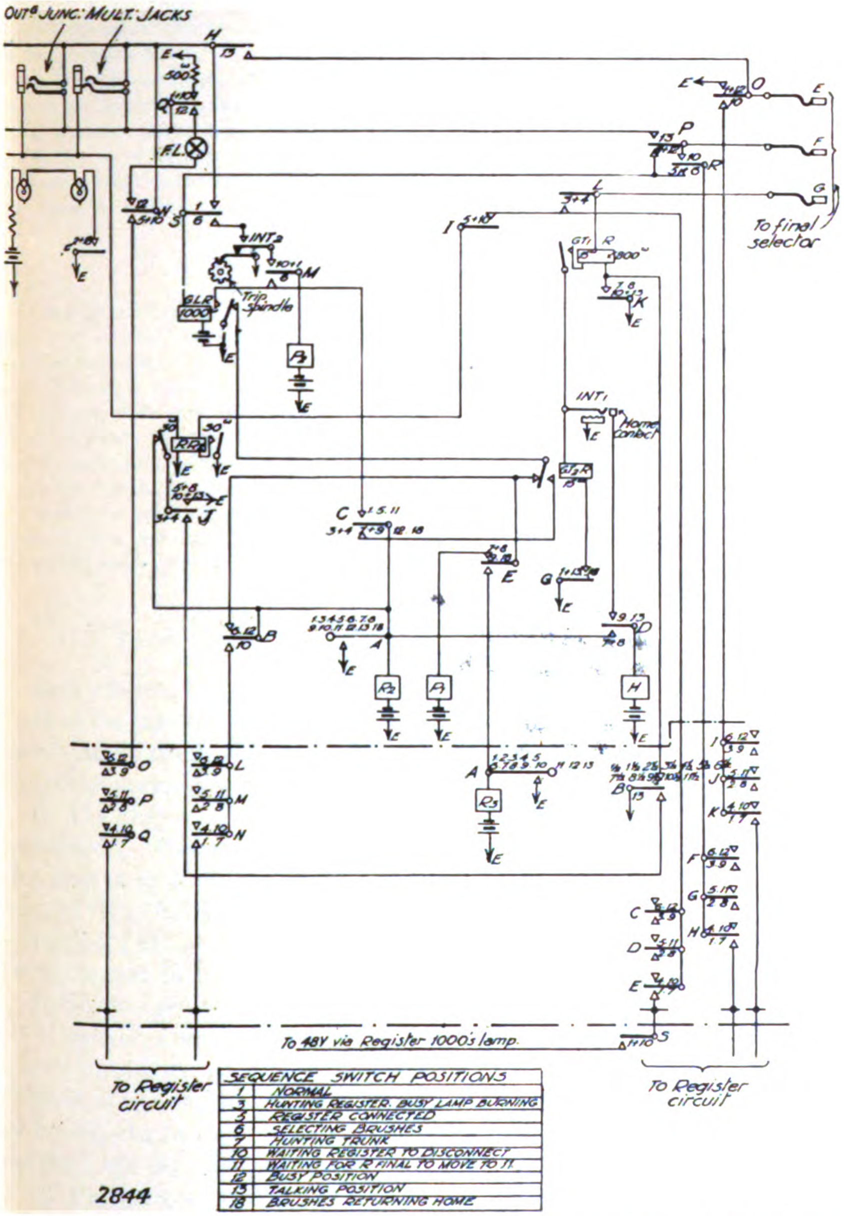
4



SEQUENCE SWITCH POSITIONS	
1	NORMAL
3	HUNTING REGISTER. BUSY LAMP BURNING
3	REGISTER CONNECTED
6	SELECTING BRUSHES
7	HUNTING TRUNK
10	WAITING REGISTER TO DISCONNECT
11	WAITING FOR R FINAL TO MOVE TO 11.
12	BUSY POSITION
13	TALKING POSITION
18	BRUSHES RETURNING HOME

31.—Junction Circuit outgoing from Manual Board to Automatic Plant *viâ* Special Group Selectors.

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(10) When operator throws the listening key associated with the calling lamp, relay OR is energised, and locks *viâ* its contacts, brush, O13 of R2, repeating coil of cord circuit to earth, disconnecting S2R of cord circuit, SOR, MOR, HOR, and calling lamp.

(11) Forty-eight volts *viâ* R1, its contact C9, contacts of S2R to earth. R1 operates and moves to position 10.

(12) The operator informs the subscriber that the wrong number has been dialled, and gives any information desired.

(13) When the subscriber replaces his receiver and the operator restores the listening key, the release of the switches is effected, as previously explained. The call is not metered, the conditions being similar to those indicated for the "Dead Number Circuit," as R2 passes the metering positions before R1 reaches them.

DEAD THOUSAND CIRCUIT (26).

In those cases where a subscriber dials a number commencing with a wrong thousand digit, *i.e.* any number above 2, a special circuit has been devised to deal with such calls on the register circuit.

(1) Forty-eight volts *viâ* relay MR2, Q2 of R4, "e" contacts of RG 1000 to earth. MR2 operates *viâ* its 1000ω winding.

(2) Forty-eight volts *viâ* N2 of R4, lamp WNL, 240ω winding of MR2, its contacts to earth, thus locking relay MR2. Lamp WNL glows and signals the test clerk.

(3) Test clerk inserts plug into jack LJ, and comes in series on the B line, *viâ* the tip and sleeve of the jack. By means of the testing equipment he can supply talking current to the subscriber, and throw his telephone set in circuit in order to inform the subscriber that a wrong number has been dialled.

TEST SELECTOR CIRCUIT (35, 36 AND 37).

Each 200-line unit is fitted with a special selector associated with a jack on the test clerk's desk. Each circuit enables the test clerk to obtain direct connection with any subscriber's line in the unit with facilities for making separate tests internally and externally, as follows:

(1) The plug of the testing circuit is inserted into the jack of the test selector. Twenty-four volts *viâ* 83ω resistance sleeve of testing plug, bush of jack, relay RR3 to earth. RR3 operates and energises relay RT1R; the latter locks *viâ* its contact, and also closes circuit for relays RT2R and RRR. RT2R joins the stepping relay SR1 of the register set to the test selector jack.

(2) Forty-eight volts *viâ* contact O1 of register, relay SR1, contact H1 of register, contacts of relay RT2R, loop of test selector circuit, contact L1 of the final selector to earth. SR1 operates and sequence switch R of the register moves into position 4, and tone sent over line *viâ* IC and M4 to indicate that dialling can commence. Relay MR1 energised, via O4 of register set.

(3) Forty-eight volts *viâ* RG 100, contact "b" contacts F4, contacts of relay DR and MR1 to earth *viâ* SR1. *RG 100 moves to position 1.* This latter operation enables relay DR to operate *viâ* its 1000ω winding, and RG 100 is disconnected from the dialling circuit. Relay SR1 now responds to the impulses sent from the test clerk's dial; the setting of the register, and control of the final selector by

the register is effected in a similar manner to that already explained for calls between two automatic subscribers.

As the testing register and final selectors differ slightly from those used for ordinary connections the sequence of operations will be briefly referred to. Assume that the test clerk desires to test 2272. The jack on the test desk associated with the 2200–2300 final selector will be plugged into, and 272 dialled. It is necessary to dial 3 numbers instead of 2 as in other systems, in order to select the odd or even hundred in the final selector.

(1) During the short interruption, SR1 and DR de-energised.

(2) After the short interruption, relay SR1 is again energised, and then 48 volts *viâ* RG 100, its "b" contact, F4 of register, contacts and 14ʷ winding of DR, contacts of MR1, and SR1 to earth. *RG 100 moves to position 2.*

(3) Relay DR energised, as explained under item (9) "Finding a free register."

(4) During the long interruption, MR energised, and R of register moves to position 7, MR1 de-energised.

(5) Forty-eight volts *viâ* RG 100, its "b" contact, P5 of register to earth. *RG 100 moves to position 3.*

(6) When the long interruption is finished, MR de-energised, MR1 energised, SR energised, and 48 volts *viâ* RG10, its "b" contact, E 7 of register, contact and 14ʷ winding of DR, contacts of MR and SR to earth. *RG10 moves to position 1.*

(7) After the impulses for the 10's digit, RG10 will be in position 7, and R of register will move to position 10, and give RG U its first step.

(8) After the impulses for the units' digit, RG U will be in position 2, and R of register will move to position 12, and as RG 100 is in an odd position, No. 3 (see item 5), relay HTR will be energised *viâ* J12 of register, and "e" contact of RG 100, and will remain locked *viâ* "e" contact of RG U.

(9) In position 12 of register, the controlling circuit is completed, and 48 volts *viâ* FLR of final selector, contacts of RT2R, H12 of register, SR1, M12 of register, contacts of AR to earth. F2R and SR1 energised.

(10) Forty-eight volts *viâ* R final, its contact C1, contacts of FLR to earth. R final moves to position 2, P2 energises *viâ* FLR, and trip spindle rotates.

(11) The selection of the subscriber's line is now similar to that indicated for an auto. to auto. call. RG10 and RG U are in their home positions, and the register sequence switch R is in position 16, then RG 100 is stepped back to normal *viâ* F16, contact and 14ʷ winding of DR, I16, contacts of SR1 to earth.

(12) When RG 100 reaches its home position, the register sequence switch returns to normal, first to position 17 *viâ* its contact C16, "d" position of RG 100, F16, contacts of DR, etc., to earth on SR, and then to position 18 *viâ* B17, "d" position of RG10, E17, contacts of DR, etc., and finally to position 1 *viâ* B18, "d" contact of RG U, D18, contacts of DR, etc.

(13) When the register sequence switch leaves position 15, relays RRR, RT2R, and RT1R are disconnected at contact L, and then R final energised *viâ* its contacts B6, contacts of RT1R, and M6 to earth. R final moves to position 7.

(14) The subscriber's line is now connected to the jack on the test clerk's desk *viâ* contacts L and K of R final, and the circuit is available for testing as desired, or listening in on an existing connection, without disturbing the conversation.

EXTERNAL TEST.

By depressing the "test out key," test relays FT1R and FT2R are associated with the COR circuit of the subscriber's line; if the circuit be disengaged these 3 relays operate. Relay TCR is energised *viâ* the earth on relay FT2R, and the jack on the test desk is then directly connected with the line of the subscriber *viâ* contacts of L and K, contacts of relay TCR, brush A and B of final selector. Voltmeter tests of the external circuit can now be made in the usual way.

INTERNAL TEST.

The depression of "test in key" operates relay TCR only, and thus enables the test clerk to operate the line relay of the subscriber's line, similarly to an ordinary call from a subscriber, and make test calls as desired.

OPERATION OF STEPPING KEY.

The stepping key enables the test clerk to pass from one subscriber to another in a complete arc, and thus facilitates the maintenance testing. When R final reaches position 7, the depression of the key completes the following circuits:

(1) Forty-eight volts *viâ* SCR to earth, operating SCR.

(2) Forty-eight volts *viâ* FLR, contact I7 of R final, relay S1R, contacts of stepping key, to earth *viâ* contacts of SCR.

(3) Relay FLR and S1R operates, and the earth on contacts of S1R causes FLR and S1R to remain locked.

(4) Forty-eight volts *viâ* R final, its contact C7, contacts of FLR to earth. R final moves to position 8.

(5) Forty-eight volts *viâ* P1, F8, contacts FLR to earth. Brush carriage rotates over one set of contacts, and this places earth from INT1 *viâ* J8 to I8, thus short-circuiting relay S1R and causing it to release. FLR is also disconnected when earth removed from INT1.

(6) Forty-eight volts *viâ* holding magnet H, E8 of R final, contacts of HCR, H8 of R final, contacts of FLR to earth.

(7) Forty-eight volts *viâ* slow-acting relay HCR, H8, contacts of FLR to earth. HCR operates and releases holding magnet H, and P1.

(8) The depression of the stepping key again repeats operation 5, thus affording the desired facility for stepping round the final selector bank.

R FINAL RELEASED.

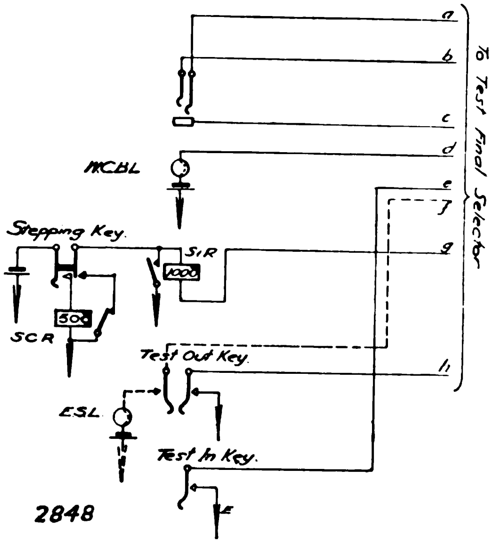
When the test clerk removes the plug from the jack, relay RR3 is de-energised. R final is then energised *viâ* B8 and passes to position 18. This operation de-enegises FLR, and then P1 is operated *viâ* F18 and returns to normal. Relay FLR is now again energised *viâ* I18 and home contact of INT 1, and R final then operated *via* C18, and passes to position 1 and disconnects FLR. When R final reaches position 9, the trip spindle magnet P2 is operated *viâ* G9 and returns to normal.

The foregoing completes the description of the various circuits on the automatic plant. The details of the miscellaneous equipment will now be briefly referred to.

Test Desk.—The switchboard circuits, howler circuits, and testing circuits are similar to those fitted on test desks for manual C.B. equipments. The following additional facilities are also provided:—

Testing Circuit.—An additional key is provided for holding the circuit under test, and transferring the testing keys to a second testing plug. A key is also fitted to enable the test clerk to use the dial associated with the cord circuits. A key is provided to bring into operation the dial testing circuits.

Testing Circuit to Final Selectors.—One for each 200-line final selector. The facilities afforded have already been dealt with (**35**, **36** and **37**).

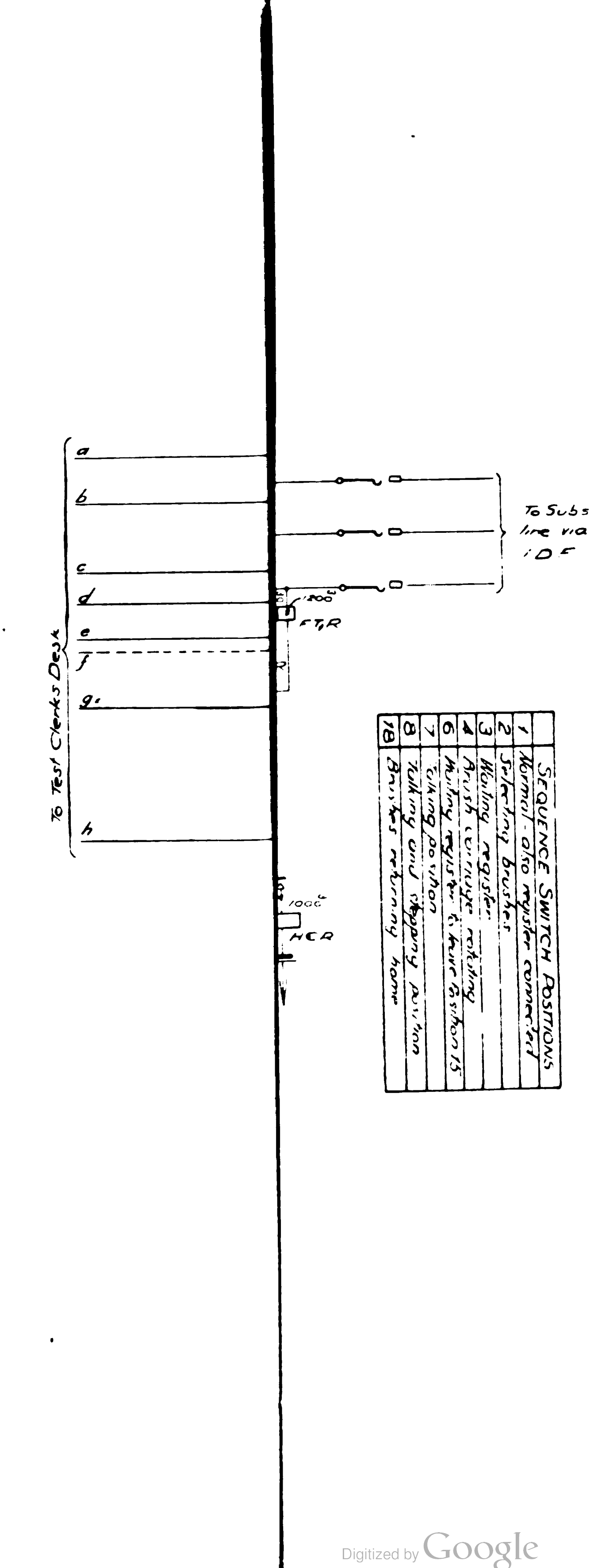


35.—TEST CLERK'S TESTING SELECTOR CIRCUIT.

Faultsmen's Incoming Test Lines.—Ten per position. When a faultsman dials 16 he obtains the test clerk direct *viâ* a circuit similar to that used for calls incoming to manual board (**30**), thus enabling tests to be made direct on the circuit, without any plugging up at the main frame.

Cord Circuits.—Five per position are provided. They are similar to the standard manual C.B. cord circuit.

Supervisory and Plugging-up Circuits.—Twenty per position are provided. The facilities afforded will be apparent from (**38**). The circuit conditions on the "Exchange" side are similar to those afforded on the dead number circuit; the ringing relay RGR is tripped *viâ* 500$^\omega$ winding and 24^v, but the supervisory relay S_2R of the group selector is not energised owing to the opposing 24$^\omega$ and condenser in the line. This arrangement is necessary in order that



	SEQUENCE SWITCH POSITIONS
1	Normal - also register connected
2	Selecting brushes
3	Waiting register
4	Brush carriage rotating
6	Pulling register to home position 15
7	Talking position
8	Talking and stopping position
18	Brushes returning home

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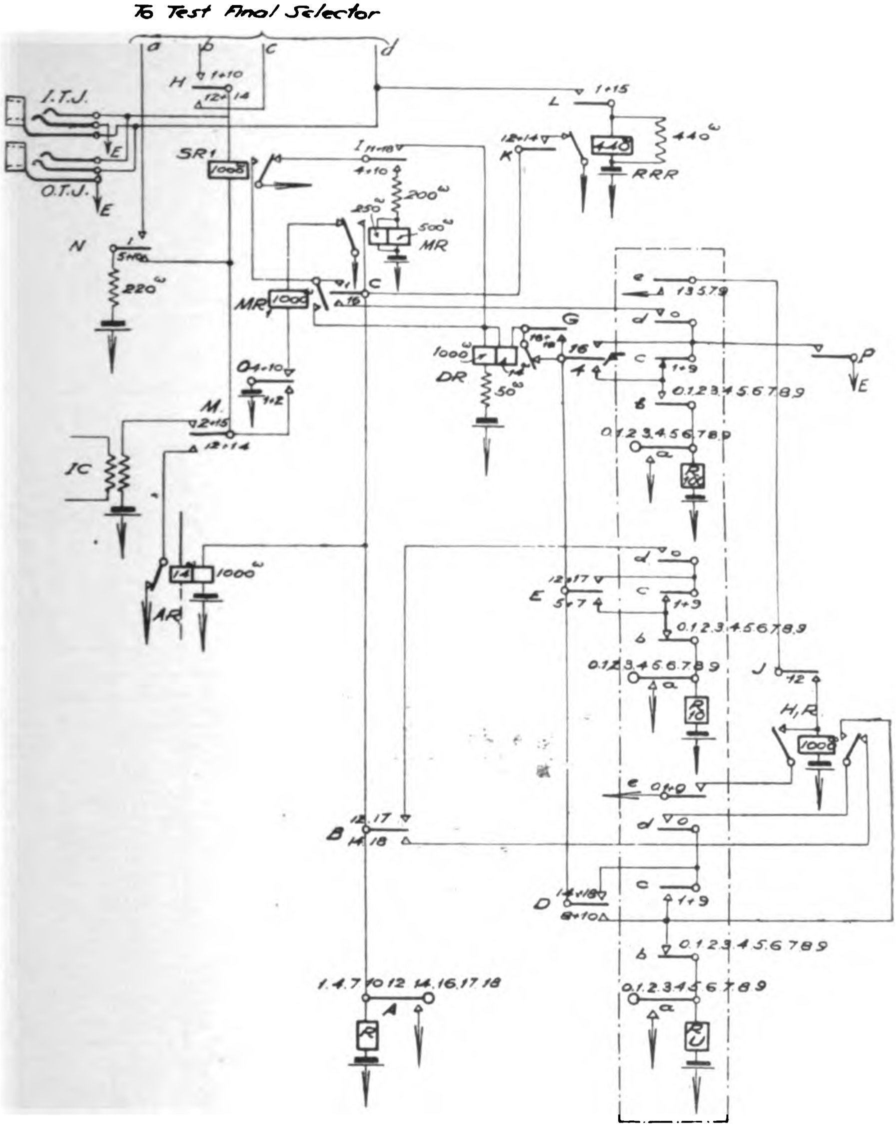

SEQUENCE SWITCH POSITIONS.	
1	Normal.
4	Waiting Subscriber to dial and receiving 100's Impulses
7	Receiving 10's Impulses
10	Receiving Units Impulses
12	Sending Tens Impulses
14	Sending Units Impulses
16	Register disconnected Sending R-100 home
17	Sending R-10 home (Premature Release)
18	Sending R-U home (Premature Release)

2850

37.—Test Clerk's Register Circuit.

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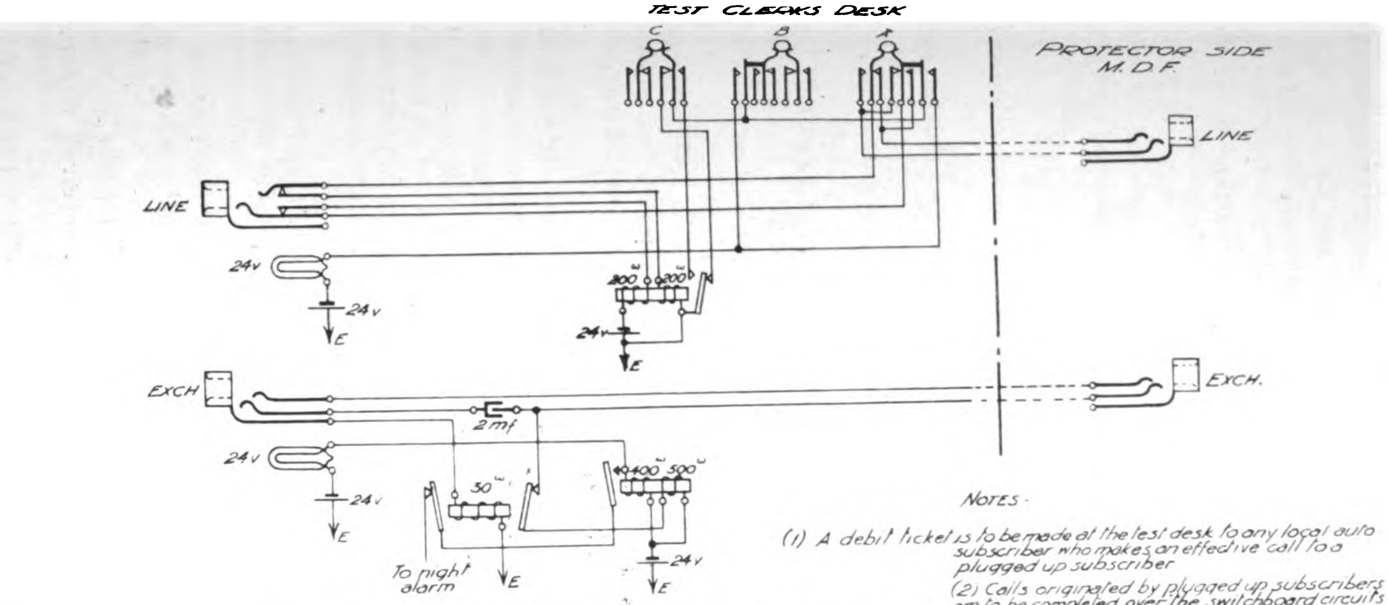

NOTES -

(1) A debit ticket is to be made at the test desk to any local auto subscriber who makes an effective call to a plugged up subscriber

(2) Calls originated by plugged up subscribers are to be completed over the switchboard circuits on the test desk, a debit ticket to be made out in the case of effective local calls

(3) Pegs for inserting in the "line" jacks indicating that service cannot be given on them owing to the nature of the fault, are to be stored in holes in jack spacing strips on the test desk. The supply of these pegs & strips is to be arranged for locally.

The keys to be thrown for the various external faults are. Fault	Keys thrown
Earth on 'A' line	A
Battery " 'B' "	A
Earth " B "	B
Battery " A "	B
Short circuit	B
Disconnection	B & C

Emergency Service on plugged up lines is given by means of the test desk cord circuit at the discretion of the test clerk as follows - Fault	Keys thrown
Earth (not full) on 'A' line	B & C
" " " 'B' line	A & C
Calling Device	B & C

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38.—Test Clerk's Supervisory, Test, and Plugging Up Circuits.

calls incoming to plugged-up subscribers shall not operate the meter of the calling subscriber.

REGISTER CIRCUIT SUPERVISORY LAMPS (**26**).—Lamps 1000S, 100S, 10S, US, glow whilst the register circuit is receiving and transmitting the impulses from the subscriber's dial.

Continuous glowing of these lamps may indicate any of the following conditions :

(*a*) Subscriber's line, earth or short circuit.
(*b*) Subscriber's dial faulty.
(*c*) Junctions to final selectors engaged.
(*d*) Register circuit faulty.
(*e*) Group selector or final selector faulty.

When such conditions arise, the test clerk, by means of a special register test plug, can—

(*a*) Rapidly locate the fault, by plugging into the listening jack, LJ.

(*b*) Converse with the subscriber if the fault is not external to the exchange.

(*c*) Hold the group selector circuit by means of key CCHK, or release it by means of key CCRK.

(*d*) Restore the register set to normal, or hold .t engaged by means of keys associated with the register test plug.

These facilities ensure that the test clerk shall be notified at once if the calls are not passing through the automatic switches satisfactorily. They also enable him to deal with any class of fault and afford temporary service where possible.

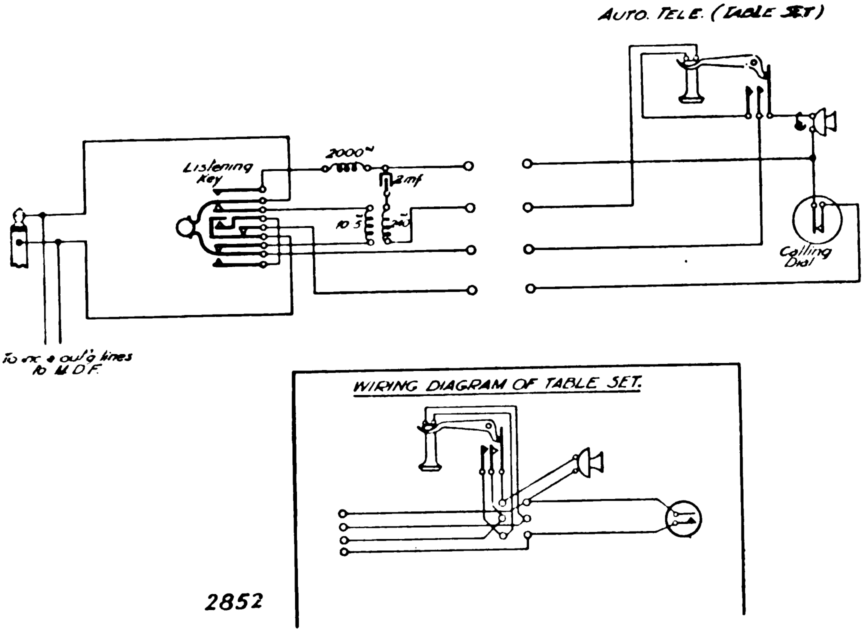
In addition to the foregoing testing facilities there are two jacks marked ITJ and OTJ, fitted on the rack accommodating the registers (**26**). These jacks enable the test clerk to test the register circuits for the reception and transmission of impulses from subscribers' dials as follows: To test for reception, a portable register "In" test set is used, which is fitted with a hand telephone, a dial, a key for testing the dial *viâ* 1000^{ω} and short circuit, a key for testing the dial with a line leakage of 10000^{ω}, a release key, and a plug.

The plug is inserted into the "In" test jack, ITJ, and numbers are set up on the registers by means of the dial under any of the above conditions.

To test the register for transmission, a portable register "out" test set is used in conjunction with a reverting impulse test circuit mounted on the register racks.

The register "out" test set consists of a hand telephone, two plugs and a key for starting the apparatus in the reverting impulse test circuit.

The reverting impulse test circuit consists of a test jack, a trip spindle and interrupter springs, and relays for starting and releasing the trip spindle. One plug of the register "out" test set is inserted in the "out" test jack, ITJ, of the register, and the other plug in the test jack of the reverting impulse test circuit. By depressing the starting key the register circuit under test controls the trip spindle and the test clerk can see from the indicator on the top of the spindle if the correct number of steps has been made by the register. It will be evident from the description of the automatic circuits that efficient maintenance of the register circuits is of extreme importance, hence the provision of this special register supervisory and testing equipment.



39.—SUPERVISOR'S DESK TELEPHONE CIRCUIT.

Supervisory Alarm Signals.—In addition to the register circuit supervisory lamps fitted on the test desk, the following alarm signals are provided:

(1) If the calling line cannot find a free line finder and group selector, the circuit of lamp GL is completed *viâ* contacts of relays GR and CR to earth (**20** and **21**).

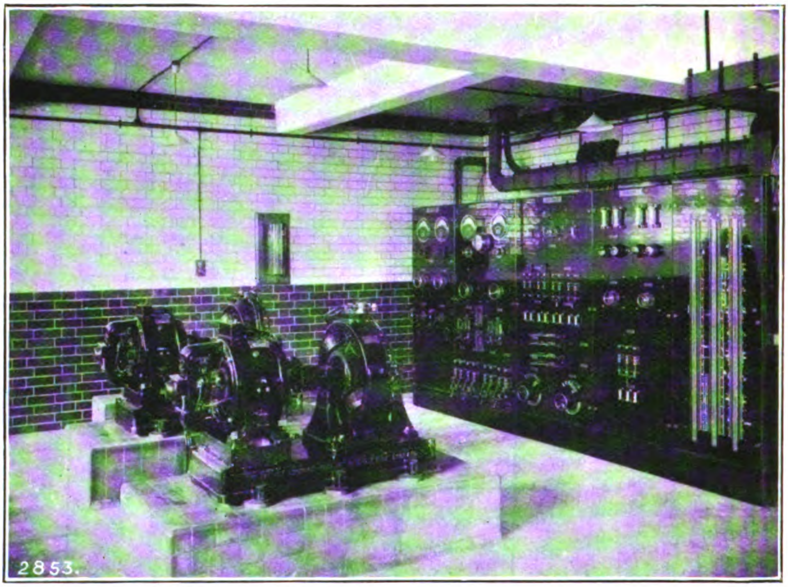
(2) Whilst the register set is receiving impulses and transmitting them to the group and final selectors, the circuit of lamp RGL is completed *viâ* contact F of R4 (**22**).

(3) If the originating subscriber leaves his receiver off after the called subscriber has restored his receiver, the circuit of lamp KTL is completed *viâ* C15 of R1 contacts of S2R to earth (**22**).

(4) If the mains-driven ringer, which is in use during the day, should fail, either on account of a fault in the supply mains or in the ringing machine, a ringing alarm relay normally operated will be de-energised and complete the circuit of an alarm lamp or bell as desired.

(5) In the event of a breakdown in the supply mains, which drive the shafting motors, the latter will be automatically maintained in rotation, as explained later, and the circuit of an alarm lamp or bell completed as desired.

SUPERVISORS' DESK.—A one-position desk is provided, equipped with the usual key-ended switchboard circuits, listening-in jacks to operators' positions, etc. An ordinary table-set, fitted with dial, is used as the telephone circuit for all purposes, wired as shown in (**39**). For listening-in conditions, the listening key is thrown, and the plug inserted into the jack associated with the circuit or operator under observation, thus providing the standard "tapping" circuit. The normal position of the listening key provides the usual telephone circuit for speaking on the switchboard circuits.



40.—DARLINGTON EXCHANGE: POWER BOARD AND MOTOR-GENERATORS.

POWER PLANT.—**40** shows a general view of the power board and motor generators. The complete equipment consists of two "charging" motor-generators, two ringers, one emergency motor-generator, two 11-cell batteries, two 14-cell batteries, two 24-cell batteries.

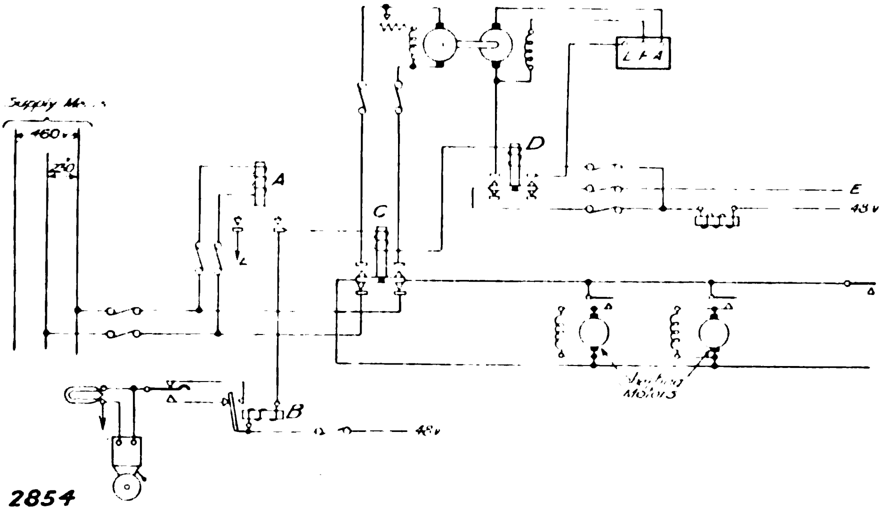
As 22 volts is used for speaking purposes on the manual and automatic equipment, and 48 volts for operating the automatic switches, arrangements are made so that—

(*a*) Either of the 11-cell batteries may be joined in series with either of the 14-cell batteries, in order to provide the 48 volts necessary for controlling the automatic switches.

(*b*) Any transposition of batteries may be effected without interrupting the circuit.

(*c*) Each battery may be charged separately and two simultaneously, thus necessitating two motor-generator charging sets.

(*d*) End-cell regulation is provided on the two 14-cell batteries in order to maintain 48 volts for the automatic plant. If necessary, five cells can be cut out of circuit.



41.—EMERGENCY CIRCUIT FOR DRIVING SHAFTING MOTORS.

Either of the two 24-cell batteries may be used as the booster-meter battery on the group selector circuit (**26**). The one not in use is charged in two halves from the 22-volt battery.

The emergency motor-generator is used for driving the shafting of the automatic plant in the event of a breakdown of the supply mains.

41 shows the normal circuit conditions, with the shafting motors in parallel across the 230-volt supply mains. Should the latter fail, relay A will be de-energised; then—

(1) 48-volt *viâ* relay B, contacts of relay A to earth, thus completing the alarm circuit of the bell or lamp.

(2) 48-volt *viâ* relays D and C, contacts of relay A to earth.

(3) Relay D operates and closes the motor circuit of the emergency set, which is automatically started.

(4) Relay C operates and places the shafting motors across the 230-volt generator of the emergency set, instead of the supply mains.

The shafting motors are thus automatically maintained in continuous rotation, and will continue to be driven from the emergency set until the supply mains are restored. Relay A will then operate, and disconnect Relays B, C, and D, thus automatically restoring the normal conditions of working.

In automatic exchanges of the "power-drive" type, it is essential that these conditions should be provided and maintained in satisfactory working order.

TRANSMISSION CIRCUIT.—The cord circuit provided for auto. to auto. calls (26) is similar to the Standard Western Electric Company's repeating coil cord circuit. The resistances of the supervisory relays have, however, been increased in order to provide a more sensitive signalling arrangement. The alteration makes the cord circuit 0·2 mile of standard cable worse from a transmission standpoint. As this cord circuit will never be used for long-distance traffic, however, the transmission loss is negligible. The cord circuit used on the manual board (6) is similar to the Department's Standard 24-Volt Stone Cord Circuit, so far as transmission is concerned.

In order to minimise the difficulties which attend the introduction of automatic switching systems, it is desirable that the whole of the operating conditions on the part of operators and subscribers (except the use of the calling dial) should be brought into use whilst the subscribers are working on the manual exchange, if such arrangements can possibly be made.

The following indicates the change-over arrangements adopted for Darlington:

(*a*) P.B.X. subscribers are provided with C.B. switchboards with calling dial and key associated with exchange lines, and C.B. telephones at extension points; speaking batteries, or power leads, and hand-generators being provided for working to the magneto exchange. Under this scheme the P.B.X. subscriber has merely to operate his dial when the transfer is made, and in the meantime he is gaining experience in operating the new C.B. switchboard which is a very essential condition as the number of automatic switches wrongly operated, owing to mistakes by subscribers, such as failure to restore holding keys, plugs left in exchange line, etc., will be much reduced.

(*b*) Other subscribers are provided with automatic telephone and two-way switch in addition to the existing magneto instruments. In the bell circuit of the latter a condenser is fitted temporarily in order that those subscribers who fail to turn the two-way switch on the day of the transfer will not originate false calls.

(*c*) Trunk circuits transferred to the new manual switchboard and operated on a junction signalling basis. On the new positions a temporary multiple of the junction circuits to the local exchange was installed. This alteration enables the operators to get accustomed to the new method of working before the transfer to automatic is effected.

The foregoing completes the description of the automatic circuits at Darlington and their operation, together with details of variations from standard C.B. practice on the new manual board, test desk, supervisor's desk, and power plant. The step-by-step method adopted in explaining the circuit diagrams may have appeared laborious, but in order to appreciate the sequence of operations and to obtain a complete understanding of the system, this method of description is necessary.

In reviewing the details of the automatic switching mechanism, readers will probably be most impressed with the new features represented by the Sequence Switch and Brush Carriage. The outstanding circuit conditions effected by the former are:

(*a*) Register circuit associated with, and then disconnected from the group selector, when the called subscriber's line is connected.

(*b*) Register circuit receives impulses from the dial, and controls the selectors simultaneously.

(*c*) Circuit "shifts" made rapidly and reliably.

(*d*) In the event of a temporary shortage of junctions to final selectors, during the busy hour, the sequence switch arranges for (1) the register to store the tens' and units' digits, (2) the group selector to rotate until an idle junction is found, and (3) then for the register to control the final selector and complete the call in the usual manner. This enables the call dialled by the subscriber to be completed, and not lost as is the case under such conditions when the selector magnets receive the impulses direct from the subscriber's dial. It is this feature that makes it possible for the size of the Western Electric Selectors to be a question of economical design only, and not one governed by the speed of the dial when operating selector magnets direct.

With regard to (*a*), one can easily imagine the development of such principles in the near future to accomplish the switching-through of successful calls *viâ* simple idle cord circuits, so that the expensive automatic selectors may be in use only whilst switching calls through *viâ* idle cord circuits, and not during conversation as at present. The salient feature of the Brush Carriage is, of course, the trip spindle and brush choosing mechanism, which determines the level, or vertical height, to be "climbed" with rotary motion only.

The whole of the automatic plant operates cleanly, and the switching apparatus is robust and of high-grade manufacture. Those readers who have had the opportunity of inspecting it report favourably on the quality of construction and design.

It now remains to be seen whether in actual practice the mechanism will perform its functions satisfactorily when operated by the very critical British public.

In conclusion, thanks are due to the Western Electric Company for the loan of certain blocks relating to the automatic apparatus.

AUTOMATIC TELEPHONE DEVELOPMENTS IN AUSTRIA-HUNGARY.

HOFRAT BARTH VON WEHRENALP, Engineer-in-Chief of the Austrian Telegraph and Telephone Administration, has sent us a copy of a paper which he read on December 12th at a general meeting of the Nordösterreichischen Gewerbeverein, on the subject of "Modern Telephone Operation in Large Towns." As the paper deals mainly with the manner in which the Austrian Telephone Administration is dealing with a problem that is facing all telephone authorities to-day, viz. Automatic *versus* C.B., we take the opportunity of furnishing our readers with the following summary of its contents.

Speaking of the technical development of central office equipment the author remarked that at the present time only three systems of operating could seriously be considered for large towns. These are: the common battery system with order wire junction working between the various exchanges of an area, the full automatic, and the semi-automatic or auto-manual system.

As regards manual operation, the common battery system, which, with an extremely simple manipulation at the subscribers' stations enables the exchange operator to supervise every conversation without listening in, gains its enormous importance only when combined with the multiple switchboard, which makes it possible to terminate several thousand lines in one exchange, and yet to effect any desired connection from any position without the aid of a second operator. But since for technical reasons the capacity of a multiple exchange cannot well exceed 12,000 lines, complete centralisation is not possible in systems of the size nowadays found existing in large towns. In consequence, special and more or less complicated means of connection must be provided for communication between the exchanges of an area. Among these, the order-wire system with speaking and signalling conductors, which was introduced into the Vienna main exchange at the outset, and was at that time adopted in most large towns, appears to be really unsurpassed even to-day as regards speed of operation. In consequence of the increased possibility of misunderstanding and wrong operating through the introduction of a second operator, however, the quality of service is very much degraded as the number of exchanges increases.

Although about fifty million connections are established per day with the manual apparatus which has been used almost exclusively for nearly fifteen years in all the large systems of the world, neither the administrations nor the public are by any means satisfied. Complaints are being made about telephone service everywhere, not only among us but also in countries which have never suffered from that chronic need of money which has been so extraordinarily detrimental to our telephones at home. In the first place, note has to be made of the fact that in all highly developed means of communication the public makes larger and larger claims as the apparatus becomes more perfect, and—because its claims are always much in advance of what is technically possible at the moment—becomes increasingly dissatisfied. Then there is the consideration that in telephony the individual himself takes part, so to speak, in the service, and therefore feels keenly all the minutest disturbances which are quite unavoidable in so subtle an operation, while he is not in a position to appreciate what is going on at a given moment in the whole system.

It is a fundamental disadvantage of manual operation that owing to the practice of connecting the subscribers to definite operators' positions the work cannot be uniformly divided between the various positions. Consequently, on the one hand, the system is uneconomical; on the other, delays and wrong connections occur at the over-loaded positions, while on account of the contracted construction of the switchboards the remaining operators, who at the moment are less busy, cannot effectively assist. Only since automatic telephony has produced reliable selecting switches has the problem of distributing calls automatically in manual exchanges appeared to be solved, at any rate so far as a single exchange is concerned. In systems comprising several exchanges, similar evils occur in greater measure in inter-exchange traffic. Engineers have sought to redress these by means of so-called Transfer System, which—if a few small installations in Rotterdam, Stockholm, etc., be excepted—exists to-day only in Hamburg, but is there employed on the largest scale. That this system, illustrating the highest degree of development of manual operation, has nowhere else come into use, in spite of the fact that the Hamburg installation has already been operating for over five years with about 50,000 lines, most distinctly shows that manual operation cannot be upheld much longer for large towns. Moreover, the real purpose of the transfer system can now be served in a much more certain and economical manner by machine-operated systems, which appear to be sufficiently developed for use even on the largest scale.

The author then outlined briefly the development of automatic telephony from its first beginnings in America to the time of its appearance in Europe. Siemens and Halske, of Berlin, have now installed automatic and semi-automatic exchanges in Altenburg, Munich, Amsterdam, Danzig, Posen, and Dresden; and the automatic exchanges of Graz and Cracow have begun operation in Austria. In England there are automatic exchanges at Epsom, Hereford, and the General Post Office. Such installations are also in contemplation at Zurich, Rome, Nice, and Marseilles, and a few more English towns, as well as in Lemberg and Vienna.

One principal advantage of machine switching is a substantially increased accuracy of operation; this is of special importance in large towns, since there every differentiation of traffic between exchanges disappears, and the operation in multi-office areas takes place just as if all the lines were connected to one central exchange. Further advantages are: a far greater speed in setting up connections, immediate disconnection on conclusion of conversation, absolute secrecy, and constant readiness for use day and night.

The single argument against automatic telephony, viz. that the public will not welcome the more difficult operation imposed upon it, is to-day already disposed of by the fact that everywhere where automatic exchanges exist the public is very satisfied. It is strikingly in favour of the automatic system, at least among us, that in consequence of the brilliantly successful operation in the sister town of Cracow, those concerned in Lemberg protested so long and energetically against the intended introduction of a manual common battery system of the most modern type that the authorities decided to withdraw the orders already placed, and to erect in Lemberg a full automatic exchange, which will be working at the end of 1914.

The changing over from manual to full automatic working presents difficulties in very large systems, because the conversion cannot be made at one stroke, and more or less complicated provisional arrangements are necessitated, the choice and the handling of which cannot well be left to the public. For such cases the semi-automatic system offers a very desirable intermediary. It is also exceptionally suitable for permanent use in the case of traffic with stations to which the public have general access (hotels, cafés, etc.), and for party lines. It is distinguished from the full automatic system in the selecting of the numbers being effected by the telephone operator instead of by the subscriber. Everything else, testing of the line desired, making and clearing the connection, is accomplished quite automatically, so that the advantages of automatic working make themselves felt to the full; the subscriber retains the simple substation apparatus of the ordinary C.B. system, whether he is speaking from a direct line, a party line, or an extension station.

In this state of affairs, the decision with regard to the future mode of operation in Vienna could only be in favour of the automatic system; and it would have been a great and almost irreparable error not to take advantage of the present favourable situation to make the change. At present the system is not too large, and the existing exchanges are at the limit of their life; a contrary decision would doubtless soon have been bitterly regretted by the public and by the administration.

There only remained the question whether the change should be made in a radical fashion by the immediate introduction of the full automatic, or whether the way should be prepared by the temporary installation of a semi-automatic system. In regard to this it seemed, at any rate, more prudent to afford subscribers, for the present, the help of trained operators; and only when machine switching has been installed throughout the area to give those subscribers who are willing to dispense with the operator's assistance an automatic apparatus in exchange for the simple C.B. apparatus, which could be made use of elsewhere.

Technically, every precaution has been taken to ensure the most thorough certainty of operation. The "Dietl system," which has been chosen, and which is based upon the connections which have found most approval in the automatic exchanges of Graz and Cracow, has been tested to the minutest details; the switches have been subjected to time-tests corresponding to thirty years of working; and most ingeniously contrived signalling devices take care that sources of error which may arise are obviated before they can cause disturbance. For private branch exchanges with more than three exchange lines, a new apparatus has been provided which enables these exchanges to be called with only a single number, a disengaged exchange line being automatically selected for each connection. The supply and installation of all the exchanges has been handed over to the best known firms here, the Telephonfabrik-Aktiengesellschaft vormals Berliner, the Siemens & Halske Aktiengesellschaft, and the Vereinigten Telephon- und Telegraphenfabriks Aktiengesellschaft of Czeija, Nissl & Co., who, since the installation of the apparatus for Graz and Cracow, are advantageously placed for manufacture.

For the future of the telephone service of a large town, however, not only the right choice of method of operation, but the capability of development of the installation is of decisive importance; and in this respect, too, the new installation at Vienna need not fear comparison with any other large town. Thus, for the present second equipment a possible development up to 100,000 subscribers was provided for, and the number, size, and position of the exchanges was determined beforehand in accordance with this capacity. By subsequently concentrating the cable network, increasing the number of exchanges, and building-in fourth selectors for a sixth digit, the installation can be developed in systematic fashion far beyond the present proposed limit even up to a million subscribers. The largest part of this extensive project is already finished.

Of the new automatic exchanges these in the Afrikanergasse, Taubstummengasse, and Zollergasse will be brought into use at the beginning of 1914, the Meidling, Hietzing, and Simmering exchanges in the middle of 1914, and the Neutergasse and Floridsdorf exchanges at the end of 1914; at the same times the corresponding existing exchanges and the provisional Zollergasse exchange will be givèn up. In 1915 there will follow the Krugerstrasse and Dobling exchanges, and in 1916 those of the Rasumofskygasse and Hebragasse.

In order to put subscribers connected to the automatic exchanges into communication with those of the old main exchanges, extensive temporary equipment had to be provided, also in the old Dreihufeisengasse and Berggasse exchanges. As conversion proceeds more and more quickly this intercommunication traffic will very quickly decrease, until the Dreihufeisengasse and Berggasse manual exchanges are at length so far vacated that they can be reconstructed for machine switching.

From this time, *i. e.* from about 1916–17, the whole of the Vienna service will enjoy the advantages of automatic working. Naturally the carrying out of this programme of conversion, which is now already settled in all its details, forms no light task, and will make the severest calls on the whole staff. Since, however, there is no doubt of the active support of the public, and particularly of the daily press, it is to be hoped that the harmonious co-operation of all interests affected will enable us to pass through this unavoidable transition stage with the least possible friction. Vienna will then have a telephone service suited to the severest requirements which can reasonably be made of this medium of communication.

TELEPHONE PROGRESS IN LONDON.

By C. W. MUIRHEAD.

THE development of the London Telephone System during the year which closed on the 31st March, 1914, followed fairly closely the lines foreshadowed in the article reviewing the previous year's progress. The results of the efforts in the direction of improving the service were clearly apparent during the year, and there is no exaggeration in the statement that London, taken as a whole, is now enjoying a more efficient service than at any previous time. The development in the size of the system during the year was not so marked. An increase of some 15,000 stations, about the same as in the preceding year, although perhaps, in the circumstances, not unsatisfactory, was scarcely commensurate with the size of the system or with the population of the area served by it. An appreciably greater increase would have been shown had it not been for the exhaustion of a number of ex-national exchanges at or soon after their transfer to the Post Office system. There was cessation of effort to obtain new subscribers in the areas served by these exchanges, and in the case of other exchanges with switchboard capacities approaching exhaustion there was necessary relaxation of effort to obtain orders for additional lines. The efforts made to overcome these difficulties, especially in the West End, should afford considerable relief in the near future.

The following list shows the 80 exchanges existing on the 31st March, and the lines and stations connected with them:

Exchange.	Stations.	Lines.	Exchange.	Stations.	Lines.
Avenue	13089	6041	Brixton	2915	2356
Bank	3212	1379	Bromley	2012	1735
Barnet	684	588	Burgh Heath	243	223
Bartholomew House	598	501	Central	18253	10363
Battersea	2336	1819	Chigwell	50	45
Bexley Heath	184	158	Chingford	120	115

TELEPHONE PROGRESS IN LONDON.

Exchange.	Stations.	Lines.	Exchange.	Stations.	Lines.
Chiswick	1690	1400	Official Switch	480	347
City	16657	8628	Paddington	8464	5550
Cray	90	86	Palmer's Green	742	631
Croydon	2667	2130	Park	3737	2803
Dalston	3612	2846	Purley	796	742
Dartford	263	119	Putney	2453	2091
Ealing	1759	1483	Rainham	59	38
East	4481	2814	Redhill	461	383
East Ham	676	546	Regent	7746	4083
Enfield	588	487	Reigate	294	241
Epsom	467	394	Richmond	1742	1456
Erith	217	151	Romford	254	203
Esher	313	284	Sidcup	307	273
Finchley	1826	1587	Southall	260	130
Gerrard	19532	6849	Stratford	1029	835
Hammersmith	1824	1372	Streatham	2079	1812
Hampstead	7967	6716	Sutton	1199	1062
Harrow	564	465	Sydenham	2350	1954
Holborn	10119	4643	Tilbury	262	198
Hop	6749	3814	Tottenham	1079	726
Hornsey	2471	2195	Treasury	276	182
Hounslow	310	255	Trunk	151	123
Ilford	748	630	Victoria	14372	6292
Kensington	7385	4700	Waltham Cross	263	191
Kingsbury	131	100	Walthamstow	836	658
Kingston	1999	1591	Wanstead	609	535
Lee Green	1886	1644	Wembley	224	182
London Wall	18289	8115	Western	6597	5239
Loughton	150	134	Willesden	1902	1584
Malden	143	128	Wimbledon	1722	1455
Mayfair	9530	6028	Woodford	326	290
Merstham	88	79	Woolwich	818	589
Mitcham	154	116			
Molesey	310	271	*Totals*	240870	146175
New Cross	2511	1809			
North	5119	3365			

The total figures compare as follows with the figures for the preceding year :

	Stations.
Year ended March 31st, 1914	240870
,, ,, 1913	226234
Increase	14636

The increase compares with an increase of 14,731 for the preceding year over the 1912 figures.

With adequate plant and consequent resumption of normal canvassing, the rate of increase of 15,000 per annum could be very appreciably increased. Careful development study shows that the number of stations connected with the London Telephone System in 1922 should nearly reach 500,000, that is to say, in eight years the system should double itself. This estimate gives a progressive increase starting with an increase of 18,500 during the first year of the group and concluding with one of 40,000 for the last year of the group. The figures are based on the assumption that there will be unrestricted canvassing as the result of the removal of plant difficulties. Careful studies of each neighbourhood in London are now made with a view to arrive at proper estimates of the probable development from a telephonic point of view and the provision of plant and exchanges to meet the recommendations of these studies should mean in course of time the removal of plant difficulties, as well as greater speed in joining up new subscribers' lines. Mr. Carty, of the American Telephone Company, in referring recently to the latter point, emphasised the fact that his company had a larger scientific staff equipment for grappling with the complex problems of telephonic development than any other administration, and stated that one of the chief secrets of the company's efficiency lay in the fact that they planned for twenty years ahead. A similar principle is in vogue in London, and with proper appreciation of the necessity for continuous development study and with prompt and adequate measures to meet the demands of the districts studied there is no reason why results equal to those obtained in New York should not follow.

The actual number of exchanges remains the same as that of last year, no new exchange creating a new area having been opened. The new Victoria Exchange in Greencoat Place, which replaces the old Victoria Exchange, was, however, completed during the year. In order to maintain the normal development of the Victoria area an advance portion of the new exchange known as "Sub-Victoria" was opened in October, and some three months later, to be exact on January 24th, the new exchange was opened and the junctions and subscribers' lines connected with the old exchange transferred to it. The capacity of the new exchange is 9540, as compared with 5650 of its predecessor.

New exchanges to replace existing ones are also being provided at Harrow, Purley, and Romford, while new exchanges creating new areas are approaching completion at Bloomsbury and Greenwich. The exchange at Bloomsbury, to be known as the "Museum" Exchange* will have a capacity for 9540 lines, and will afford much needed relief to the group of exchanges serving the west and west-central districts. Preliminary steps have also been taken for the provision of two exchanges—Charterhouse and Tower—of the maximum size in the city area, and a site for a new and larger Holborn exchange has been obtained.

In addition to these works, switchboard extensions and alterations were carried out at a number of exchanges, notably at Battersea,

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* This exchange has since been opened.

Ealing, Hop, Kensington, and Tottenham. At the Central Exchange a new twelve-position information desk was opened in March of last year, and the desk previously used recovered, increased to twelve positions, and installed in the City Exchange in the following November. Both exchanges are now adequately provided with up-to-date facilities to deal with enquiries and other matters which cannot well be dealt with by the operators at the ordinary answering positions.

Since the acquisition of the National Telephone Company's system it has been necessary to re-arrange the areas served by a number of exchanges. In some cases an ex-National exchange and a Post Office exchange served the same neighbourhood, and it was possible to close one of the two exchanges. In other cases two areas overlapped, and it was necessary on economical grounds to assign a distinct and separate area to each exchange. These operations necessarily entailed a good deal of transference of subscribers' circuits from one exchange to another, and last year the number of circuits affected in this way was no less than 5149. In some 600 instances it was found possible to give the subscriber the same number on his new exchange as he had had on the old exchange, and the department was able to carry out the changes with a minimum of inconvenience to the subscribers. In the remaining instances a change of number was involved, and the department's proceedings, which were, of course, dictated by the needs of the system as a whole, were regarded by the subscribers concerned without perceptible sign of enthusiasm or approval.

The total number of cessations during the year was 16,618, an increase of 5193, or 45 per cent. over last year's figure. The following table shows the reasons for the cessations so far as it is possible to analyse them :

Bankruptcies.	Business bad.	Deaths.	Giving up business.	Exhibition lines.
645	1016	326	1034	495

Leaving area.	New installations.	Removed (address unknown).	Solicitor's instructions.
831	781	3935	404

Removals in connection with.	Transfers to other Exchanges.	Miscellaneous and unanalysed.
205	16	6930

The change of procedure in the treatment of cases of transfer of circuits from one subscriber to another was the principal cause of the large increase in the number of cessations. Formerly, when a subscriber gave up his premises it was customary to arrange, if possible, a transfer of the installation to the incoming tenant. It was to the outgoing subscriber's interest that this should be done, as he was reimbursed for rental paid by him for the period beyond the date when he left the premises. It is now the practice to take a new agreement from the new tenant, and tell the old tenant that rebate of rental will be given to him in respect of any period for which he has paid rental subsequent to the date of commencement of service to the new subscriber. Under this method the old subscriber, whose agreement is, of course, terminated, does not suffer through the matter not being dealt with on transfer lines, and the Department is favourably disposed towards the new procedure, which gives rise to less trouble than the old method. The number of cases dealt with on what are known as "new and ceased" lines, which would formerly have been dealt with on transfer lines, is about 200 monthly.

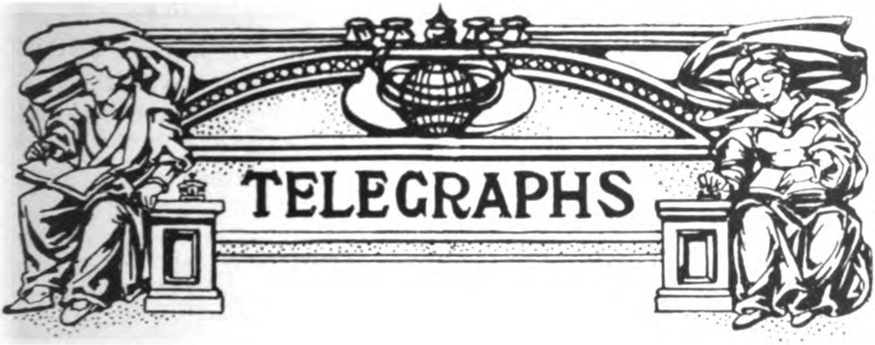
A second contributing factor—in a much lesser degree—to the increase is the cessation of extension lines by firms formerly on both the Post Office and National systems. However full and unrestrained the inter-communication between two systems serving the same areas, there is always a certain amount of duplication in the case of subscribers belonging to both systems, and in the process of straightening out, following amalgamation of the two systems, such subscribers generally find that they can dispense with some of their telephones, generally at extension points. A third reason is the reduction in the length of notice required to terminate agreements. The Post Office has always been more generous than the Company in respect of length of notice, and it soon extended its short notice system to subscribers to ex-National Exchanges. The system is convenient to subscribers, but tends to swell the number of cessations, as frequently subscribers removing to other addresses find it better to give the short notice required and take new circuits than, as was the case previously, have their installations removed.

The removals carried out for subscribers during the year were 17,989. The decrease of about 1000 on the previous year's figure was probably to some extent due to the factor referred to in the preceding paragraph. The variation in the percentage of removals to stations during the last few years will be seen from the following table:

	Stations.	Removals.	Percentage to stations.
1909–10 (Post Office)	60091	5458	9·08
1910–11 „	69035	6226	9·01
1911–12 „	77317	6830	8·83
1912–13 (Post Office and National)	226234	19005	8·89
1913–14 (Post Office and National)	240870	17989	7·47

What most characterised the telephone year in London was the marked change of opinion of the subscriber with regard to the service. At the beginning of the year complaints and criticisms were numerous. Here and there the difficulties associated with the transfer of the National Telephone Company's huge undertaking and staff were pointed out, and suggestions made that the public should be sparing of criticism until these difficulties were removed. Generally, however, the subscriber was firmly convinced that the service was bad, and bad because it had been taken over by the Post Office. With the creation of what might be termed an atmosphere of criticism, there was the usual tendency towards exaggeration of complaint. The writer lived at a place served by a much maligned southern railway company for some half a dozen years, and, on the whole, got rather a better service to town than he had obtained previously or has had subsequently. The general punctuality of the service made, however, no difference to the number and strength of the complaints when something arose to cause delay. Had the reputation of the company been higher, many cases of unpunctuality would have passed without comment. Had a similar percentage of cases of delay to cases of punctuality occurred in the case of other railway companies, less complaint would have been made against these other companies. The inference is that, given precisely the same grounds for criticism, the individual, whatever justification he may have for complaint, will more readily complain against a system about which others complain than against one about which he hears few criticisms. Such was the case a short time ago with the telephone service of London. The atmosphere of criticism had been created.

Criticism comes in waves and is seldom in proper correspondence with the service given. Quick responsiveness of the telephone subscriber to "atmosphere" does not necessarily indicate a good barometer of telephone weather. On the other hand the present comparative absence of public complaint does not necessarily imply the existence of a perfect service. The Department welcomes criticism and suggestions from subscribers desirous of improving the service, for it knows that such subscribers are generally ready to assist with their co-operation. Statistics show that the service now given in London compares not only very favourably with that given in the majority of large cities throughout the world, but also very favourably with the service given to London in previous years. Unceasing efforts are being made by the Department to secure still higher efficiency, and with increasing co-operation on the part of the public there is no reason why a service reaching the highest possible standard should not be obtained.



TELEGRAPHS

THE GULSTAD RELAY.

As the use of the Gulstad relay is becoming more frequent on the underground and submarine circuits of the Post Office, it is thought the following brief notes will be of interest to the readers of the JOURNAL. (See also 'Electrical Review' of June, 1898, and August, 1902).

The relay is a polarised one, and is constructed on similar lines to the Post Office standard relay, but in addition to the movable bridge carrying the adjustable contacts which govern the play and bias of the armature, the electro-magnets are also adjustable by means of a screw, and can be made to give a variable air-gap between the poles of the electro-magnets and the armature.

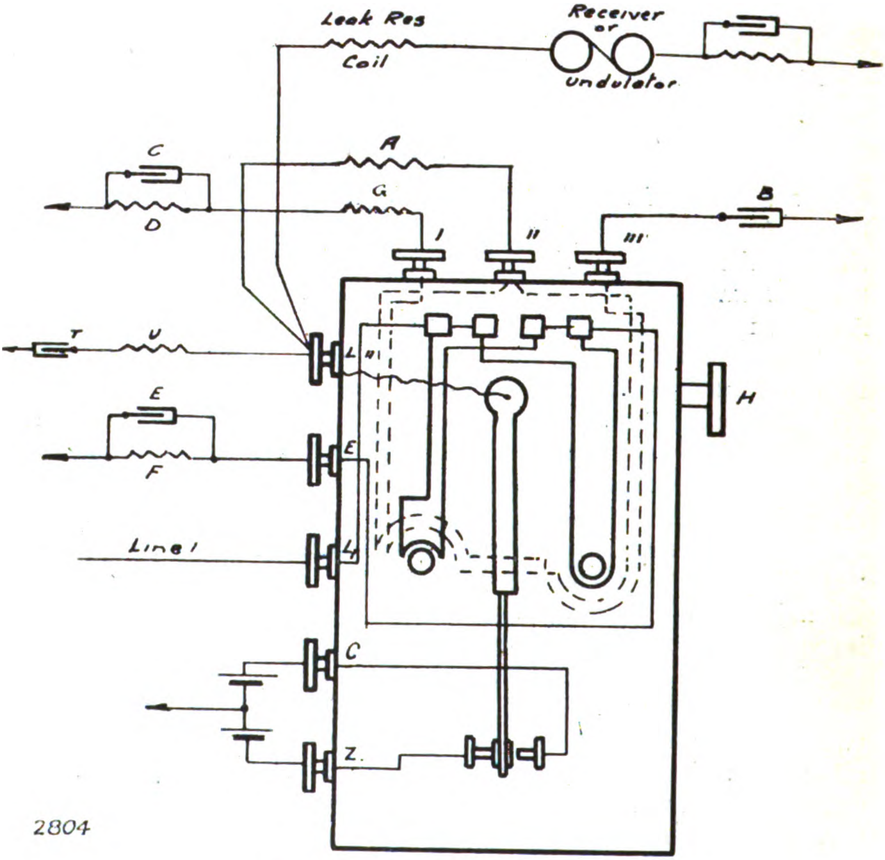
The relay is wound with two sets of coils, termed "main" and "auxiliary." The main, or line coils, have a resistance of 1000^{ω} when joined in "series." A switch is provided at the back of the instrument by means of which the coils can be readily joined up in multiple when desired, and they then have a resistance of 250^{ω}.

The auxiliary coil has a resistance of 300^{ω}; it is divided into two sections, and is connected to three terminals at the back of the relay, the resistance between each pair of terminals being 150^{ω}. If a current enter by the centre terminal of the auxiliary coil and leave by the two outer ones it will act differentially. The auxiliary coil is provided so that a local current may be introduced into the apparatus with the object of making the relay more sensitive, and converting it into an instrument able to record signals which have a varying zero line, such as those obtained from long underground or submarine cables.

The connections are arranged as shown in 1. The firm lines represent the main coils, and the dotted lines the auxiliary coils. The armature and battery connections are self-explanatory.

The auxiliary current is provided by means of a local battery, the centre of which is joined to earth, connected to the terminals *Z* and *C*, and passes from the tongue of the relay *L. II* to the centre terminal at the back of the relay through a resistance, "*A*". From the centre terminal the current traverses the right-hand coil to terminal *III* and charges condenser "*B*"; it then travels through the left-hand coil to the terminal *I* and to earth *viâ* resistance *G* and resistance *D* across which is placed condenser *C*.

The connections are so arranged that the current which passes through the right-hand auxiliary coil tends to assist the main line current; the current which traverses the left-hand coil has the opposite effect.



I.—Gulstad Relay Connections.

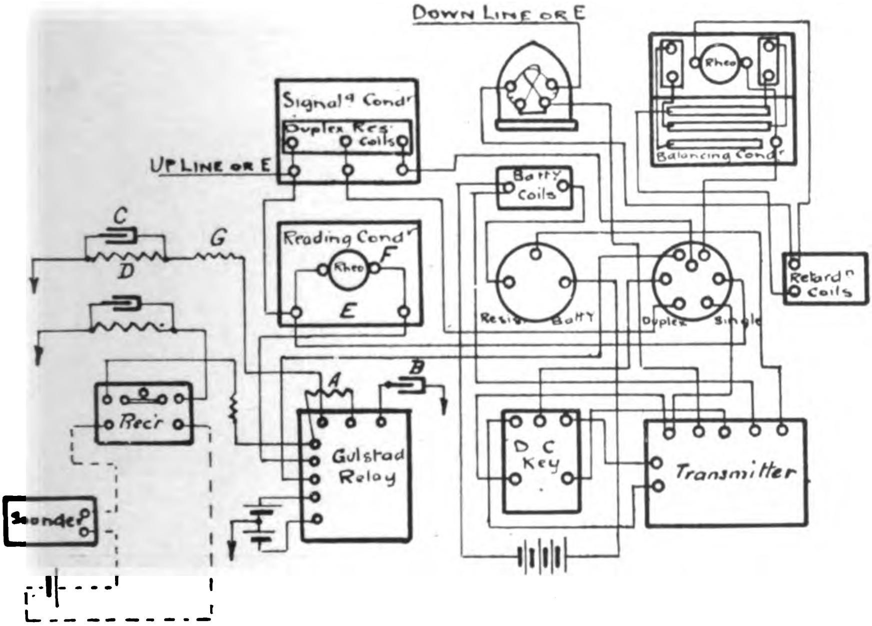
The local recording instrument, usually a Wheatstone receiver, is connected to the tongue of the relay (terminal *L. II*), and a shunted condenser is placed in series with it. Should the relay be used as a repeater the line to which the signals are to be repeated is also connected to terminal *L. II*.

The reading condenser *E* and resistance *F* are placed in series with the main coils in the usual way.

The screw *H* moves the bridge which carries the battery contacts, and a "bias" can thus be given as required.

2 shows a duplex and simplex set equipped with a Gulstad relay.

With the connections arranged as described above, and with suitable resistances and capacities in the various coils and condensers, the armature of the relay will vibrate when no current is passing through the line coils.



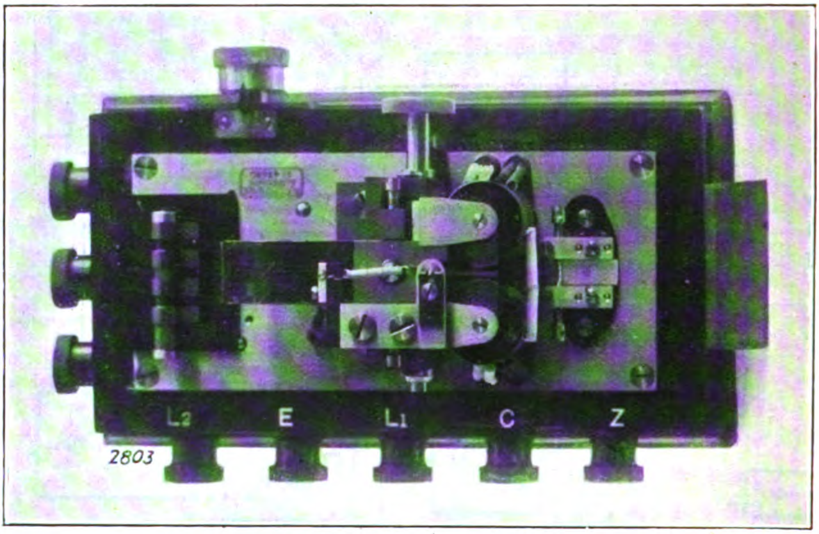
2805

2.—Duplex and Simplex Set equipped with a Gulstad Relay.

The object to be attained is first to make the relay vibrate through the action of the current in the auxiliary circuit at approximately the same speed as the reversals of the distant Wheatstone transmitter. The two systems, line and local circuits, should have such a relationship that the line current shall have the effect of stopping the vibrations for a certain length of time, depending upon the signal that is being transmitted, *i.e.* a dot or a dash. Of course these remarks apply equally to the "spacing" as well as to the "marking" currents.

One of the reasons for want of sensitiveness in an ordinary relay is the magnetic attraction between the armature and the nearest pole-piece of the electro-magnet; so that although a current may cease and even be changed in direction, some little time will elapse before the reversed current will have risen sufficiently in value to cause the armature to move towards the opposite pole-piece of the electro-magnet.

As already stated the action of the current in the auxiliary coils of the Gulstad relay is opposed to that of the line current, and if the two currents be nearly equal, then directly the line current falls sufficiently the auxiliary current will cause the armature to move to the opposite side. Thus the relay becomes very sensitive, and will respond much better to the variations in the line current; in fact it might almost be said that the relay anticipates, as it were, the action of the line current.

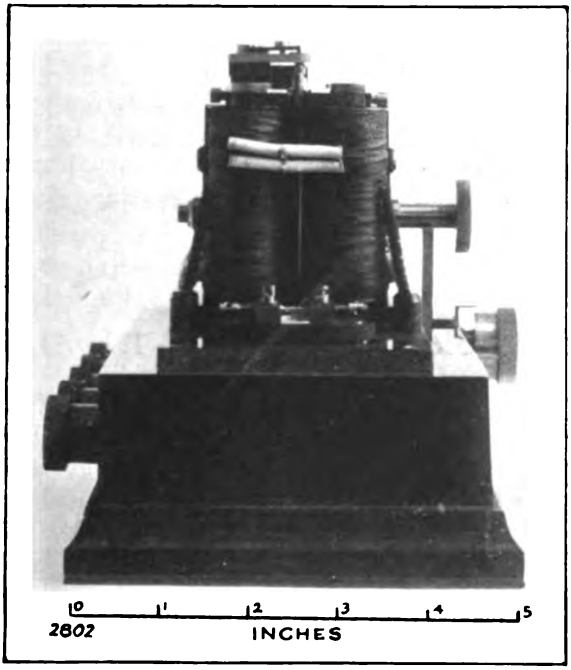


3.—Gulstad Relay. Plan.

The condenser *B*, in addition to affecting the timing of the current in the auxiliary circuit, assists materially in securing good contacts. When the relay tongue makes contact with a battery stop the charging of the condenser momentarily confirms the action of the line current, thus ensuring a good contact, and when the line current is diminishing in value prior to being reversed, and the auxiliary current causes the tongue to move away, the discharge of the condenser will move it quickly in the required direction.

The relay should not only be capable of vibrating at the same rate as the reversals sent by the transmitter at the distant office, but in addition the local circuit must be so arranged that the rise and fall of the currents in it should correspond in time with the variations of the cable or line currents. The rate of vibration will increase when *A*, *B*, and *D* are decreased, and *C* is increased in value. A slower rate of vibration will be obtained when *A*, *B*, or *D* are increased and *C* decreased.

Sparking due to induction from the line or leak is neutralised by the condenser *T* connected with the tongue, and in order that this condenser may not in itself give rise to sparking or sticking at the tongue contacts a small resistance *U* is placed in series with the condenser. Speaking generally, this has not been found necessary on the English land lines and both items have been omitted.



4.—Gulstad Relay. Front Elevation.

The rise and fall of the currents in the auxiliary circuit may be brought into harmony with those in the line by watching the effect on the signals due to altering the various resistances and capacities. The following notes will show to some extent how this may be done:

The distant station should pass through the transmitter a Wheatstone slip having on it a series of groups of, say, twelve dots, dashes, and some well-known sentence. The dots will assist in the regulations for the vibrations.

If the relay gives off nothing but dots, the auxiliary current is too strong, and the resistance *A* must be increased until dashes appear on the slip. If the signals are clipped reduce the capacity in *B* and increase that of *C*, at the same time increasing resistance *A*.

Should the dashes run together while the dots are good, or if the dots are too small when the dashes are right, the resistance in *G* should be increased, while that of *A* and the capacity in *C* should be reduced. When the signals have a tendency to break into dots of irregular size the resistance in *F* should be reduced, but if they incline to run together the value of *F* should be increased.

On an underground line or cable circuit, where the line currents do not vary greatly, the adjustments when once obtained will be found very stable, and will require alteration only when a change of speed is necessary. If a reduction in speed be desired it will generally be found sufficient to increase the resistance in *A* and *G*.

3 and **4** show a plan and elevation of the relay.

E. L.

GELL PERFORATING WORK IN AUSTRALIA.

THE following figures, which are vouched for by the telegraph manager, Perth, will, I am sure, be read with interest by the members of the home service. On December 24th, 1913 (Christmas Eve), the remarkable total of 1062 messages was perforated in 8¼ hours by a Perth telegraphist, Mr. Archibald Cruikshank. It will be seen that the average throughout the day works out at nearly 129 messages per hour. Whether this number constitutes a world record for Gell work or not I cannot say, but it will be interesting to know whether such a total has ever been reached before by a telegraphist during the course of a single day's work. Even allowing for the fact that the messages were chiefly of the short Christmas greeting type, the performance is a remarkably fine one. Curiously enough, the same gentleman holds the previous Western Australian record, having Gell-perforated 981 messages in 8 hours on Christmas Eve, 1912—an average of 122·6 per hour.

As an indication of the heavy Christmas pressure experienced in the Australian telegraph service, it may be stated that on the day upon which the above total was reached the telegraph traffic between Perth and Adelaide (1804 miles with three repeaters in circuit) was as follows:—4204 messages were transmitted from Perth to Adelaide, and 3129 messages from Adelaide to Perth. Three circuits were utilised in all, one of which was equipped with Wheatstone, the other two being hand-worked duplex circuits.

J. M. C.

[In the paper read by Mr. Newlands, Controller of the Central Telegraph Office, before the Telegraph and Telephone Society, London, on November 24th, 1913, he quoted the following number of messages punched in an hour on the Gell perforator:—79, 80, 81, 82, 84, 84, 87, 93, 100, 127, by various telegraphists, the last-mentioned total being done by Mr. Pratt . . . In a recent test at the Stock Exchange some excellent key-board manipulation was performed by Mr. Molland, but unfortunately the pressure of work during the hours was not continuous, and this left him with 13 minutes of unoccupied time. Nevertheless, he punched 111 messages containing 2025 words, including 3622 figures. He was thus punching at the rate of 142 per hour, averaging over 18 words per telegram. . . . Other trials have been made extending over four hours with the following results:—62·2, 63·7, 64, 68, 69·2, 70·7, 72.

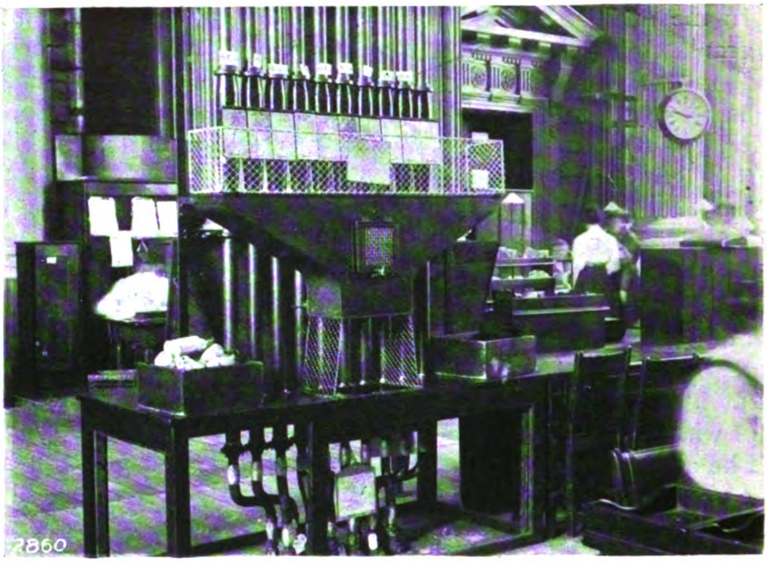
The above figures are the only home returns available at present for comparison with those of the Australian expert quoted by "J. M. C." Their publication may induce some record-breaker to supply us with authenticated figures for a whole 8-hours' duty.—Editors P. O. E. E. JOURNAL.]

THE NEW HOUSE TUBE SYSTEM AT THE C.T.O.

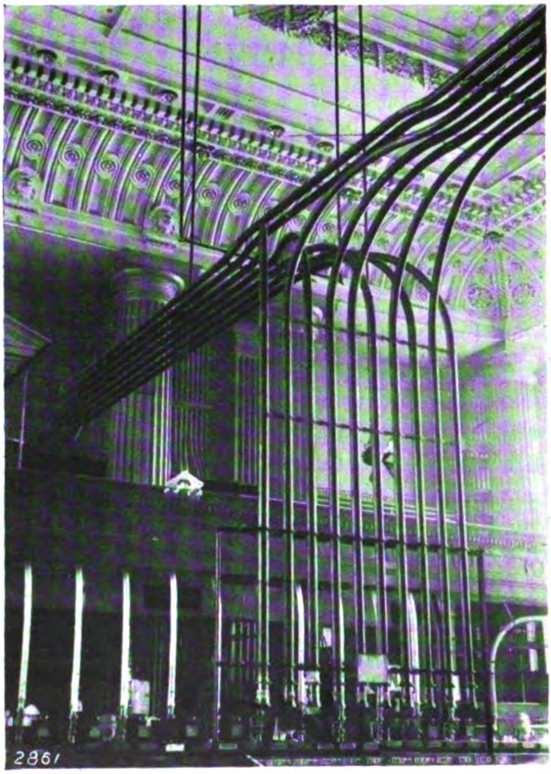
THE speeding-up process which modern requirements have recently necessitated in practically all forms of communication and transportation has also been found essential in the Department's pneumatic tube service, the largest and most recent example of which is the new house tube installation at the Central Telegraph Office.

Under the old system the house tubes were operated on the same system as the street tubes, *i. e.* by means of D. boxes and three-way cocks, the D. box consisting of a heavy metal trough in the shape of a ℧, fitted with a sliding glass cover, the tube being terminated in one end of this box, and pressure or vacuum being applied at the other end by means of the 3-way cock as required; signalling by means of glow lamps was also a necessary part of the equipment. The despatch and receipt of a carrier with messages necessitated eight distinct operations on the part of the attendants. Under the new system the number of operations is reduced to three, while the table space required for the new terminal apparatus is only about one quarter of that required under the old conditions for the same service.

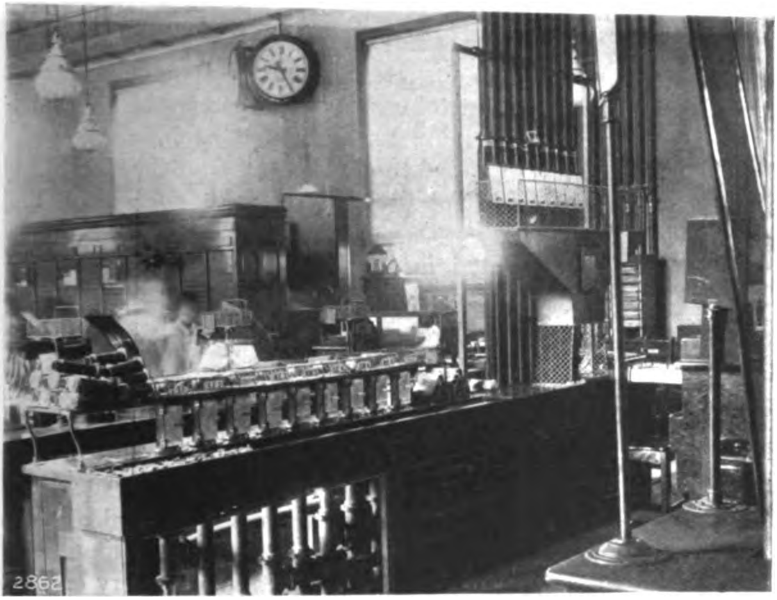
The new system will, it is hoped, shortly be adopted in all the large telegraph offices which possess a house-tube service, and the



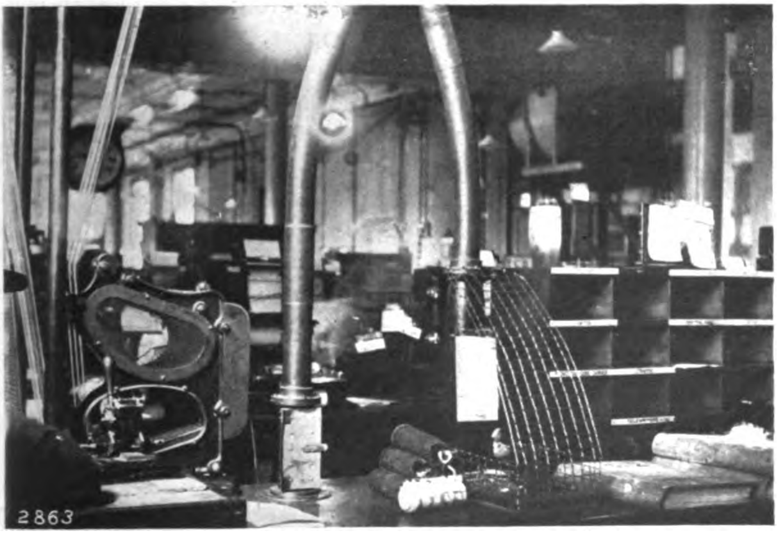
1.—Central Hall. Receiving Table for Ten Tubes.



2.—Central Hall. Sending Station showing Tube Runs.



3.—A Typical Tube Table: Sending Terminals on left and Receiving on right.



4.—Single Station, with One Sending and One Receiving Terminal.

following particulars of the Central Telegraph Office installation may, therefore, be of interest.

The installation consists of some four miles of brass tubing, 2¼ in. internal diameter, with 110 despatching and 110 receiving terminals. There are eleven main despatching and receiving tables with about ten despatching and receiving terminals on each, an "up" and "down" service being provided to each point connected; there are also five receiving and despatching points, with one or two sets of terminals.

The tubes are connected in loops of from 500 to 700 feet in length with a maximum of eight terminals on each loop, one end of the loop being open to the atmosphere and the other connected to the vacuum service through a regulating cock.

A continuous flow of air is maintained in each loop by means of a vacuum of from 6 to 16 inches of water at the service end depending on the length and nature of the loop, *i. e.* number of bends, vertical rise, etc.

The carriers are inserted either in a funnel at the end of the loop or through a spring-closed door in other parts of the loop, and are automatically discharged through a flap at the delivery end where they fall into a hopper and thence into a box on the table. The actual speed of the carriers is considerably less than under the old system, but the time of handling is very much reduced, and a continuous service is given as against an intermittent one, with the result that the work can be dealt with in a continuous stream instead of in intermittent batches; the total time required for circulation is thus reduced by as much as 50 per cent. or more.

The system, which has taken twelve months to instal, has been in operation since the middle of March. Some difficulties were experienced at first with the carriers, but these difficulties have now been overcome and the system operates quite successfully, and it is understood gives complete satisfaction to the Commercial Branch. A new type of leather carrier has also been introduced which it is hoped will ultimately expedite the handling of messages still further, as it dispenses entirely with the use of elastic, which is a source of much trouble on the old carriers.

Other steps have been taken to expedite the working of the street tubes and the author hopes to be able to give a description of the methods adopted in a later article.

I am indebted to Mr. A. B. Eason for the photographs illustrating this article and which are self-explanatory.

E. H. WALTERS.

HIGH-SPEED WIRELESS TELEGRAPHY.

A CONTRACT has been placed with the Marconi Company for erecting at Stonehaven a wireless station which, among other functions, will serve for communication at a speed of one hundred words per minute, with a similar equipment to be installed by the Company at the Cullercoats Wireless Station. The object of this provision is to supply a channel of communication with the north-east of Scotland, and in the event of breakdown of the overhead lines north of Edinburgh.

In accordance with the Department's specification, the Company were called upon to demonstrate that they could attain the speed they guaranteed—one hundred words per minute—and maintain such speed continuously for long periods, before the contract was placed. This the Company did recently with marked success, under the supervision of the Engineering Department. The traffic and wireless branches of the Secretary's Office of the Post Office were also represented at the trials. In view of the field opened up by the development of wireless telegraphy, and its probable influence on ordinary line telegraph communication, some brief description of the system and a summary of the results obtained during the demonstration will probably prove of interest to readers of this JOURNAL.

In view of the possibility that some parts of the system may be the subject matter of pending patents such description must of necessity be very general in character.

The stations chosen for the demonstration were:

(*a*) Chelmsford, the experimental station of the Company;

(*b*) Letterfrack, County Galway, the normal receiving station for the Company's Transatlantic Service.

The distance between the stations is approximately 550 miles. It should, perhaps, be added that during the demonstration all receiving of Transatlantic traffic was done direct at the Clifden station.

The manner of carrying out the demonstration was as follows:

For fast speed communication Chelmsford served as the transmitting and Letterfrack as the receiving stations, no transmitting apparatus being installed at Letterfrack. Key speed communication between the stations was effected, when Transatlantic traffic permitted, by means of the Company's Clifden station, distant fourteen miles from Letterfrack; a transmitting key at Letterfrack with lines between the two stations serving to operate a relay at Clifden, which in its turn took the place of the ordinary transmitting key there.

The only feature of the system which for the purposes of this article call for mention are those intimately associated with high-speed working; the remainder of the plant follows closely the lines ordinarily adopted by the Company for medium power installations. In regard to the transmitting plant, the frequency of the alternator is 200; a rotary disc discharger is coupled direct to the alternator shaft for synchronous working, giving a spark frequency of 400. The signalling key is placed in the high tension side of the transformer; this key consists in its essential of a rocking arm, which in its rocking completes the circuit of the high tension side of the transformer; the process of signalling, therefore, consists in rocking the high tension key to correspond with the Morse signals. The rocking of the key is effected by means of pistons attached to the ends of the rocking arm, the pistons being actuated by pneumatic pressure. Punched slip is fed into a Wheatstone transmitter at the desired speed; the Wheatstone transmitter actuates a relay of special design controlling the pneumatic supply to the pistons attached to the signalling key.

The receiving plant was that ordinarily in use by the Company for their Transatlantic traffic, but of course adjusted for the particular wave length adopted for the demonstration. It consists of an arrangement of high frequency magnifiers associated with the usual condensers and circuits coupled to the aerial, and terminating in a coupled circuit in which is placed a crystal receiver. Beyond the crystal receiver, where, of course, the high frequency oscillations are rectified, are other magnifying arrangements associated with a telephone receiver. The increase in volume of sound due to these progressive magnifications is such that the signals can be read in any part of a very large room. For fast-speed reception the signals are recorded on a dictaphone driven at a suitable speed; when a dictaphone cylinder is filled it is passed to an operator, who transcribes the messages by means of a dictaphone driven at a speed appropriate for "writing up."

The chief objection to fast-speed reception experienced in earlier fast-speed experiments, where the signals were recorded visually on a slip, was the blurring or complete wiping out of the signals when atmospheric discharges affected the aerial. The great recommendation of reception by the dictaphone method is that the effects of atmospheric discharges of strength ordinarily experienced in this country are so minimised as not to interfere seriously with the transmitted signals. The general characteristic sound in a wireless receiver of an atmospheric discharge upon the aerial is a note of low pitch. The fast speed signals are of somewhat high pitch; in the degrading of the speed for transcription, the pitch of the signals and that of an "atmospheric" are degraded in the same ratio; consequently, while the signal retains a characteristic note, the pitch of an "atmospheric" is generally degraded below that of audibility.

The method adopted for the demonstration was as follows: Dummy messages were prepared, and Wheatstone slips punched from them by the Department; the slips were run through a Creed translator, thus giving typed copies of the messages corresponding in all particulars with the slips. The typed copies were taken to Letterfrack, where all checking was performed. The checking of speeds was, of course, done at Chelmsford. The messages were average commercial messages, with the usual proportion of plain language, figure, code and cypher. Over pre-arranged times Chelmsford at first ran through slips for fifteen-minute periods, separated by intervals of fifteen-minute rests. Early in the demonstration such good results were obtained, however, that these working and rest periods were altered to thirty minutes and five minutes respectively. This condition, under which the major part of the demonstration was conducted, was much more onerous than that first adopted, and constitutes probably the most thorough and severe working test ever applied to wireless working.

At Letterfrack, dictaphone cylinders or parts of cylinders, bearing the received signals, were chosen for transcription as soon as they were taken off the dictaphone, the object being to have written up about 25 per cent. of the messages transmitted and to distribute over the whole of the cylinders the messages chosen for writing up under conditions approximating to those which would be experienced in actual working. The demonstration was spread over a period of four days; the traffic particulars for the separate days are as follows:

	Messages received.	Messages written up.	Individual errors.	Messages mutilated.	Messages lost.
1st day . .	190	47	13	3	2
2nd „ . .	588	153	1	1	—
3rd „ . .	459	95	7	1	—
4th „ . .	290	64	—	—	—
Grand total .	1527	359	21	5	2

The only marked variation in receiving conditions observed during the demonstration occurred on the first day. At times the signals would fall rapidly in strength and as rapidly rise to their normal strength again. The variation was not traced to any particular cause, but was probably due to some abnormal atmospheric condition about which little is known at present, and which affects generally all wireless systems. It will be seen that most of the faults occurred during this time. The grand totals compare not unfavourably with those obtained in ordinary line communication; eliminating the first day's traffic the results are remarkably good, and to those hitherto unacquainted with recent developments in wireless will come as a surprise.

Further short trials at higher speeds were made, of which particulars are as follows:

Speed, words per minute.	Messages received.	Messages written up.	Individual errors.	Messages mutilated.	Messages lost.
125	38	38	1	—	—
140	20	5	—	—	—

It will therefore be seen that the system promises to be capable of maintaining speeds much higher than 100 words per minute.

The possibility of actuating the transmitting apparatus from a distance will be obvious to all engineers, and when it is added that the Company has further demonstrated that the received signals can be relayed over a considerable distance, the flexibility of the system will be recognised. It would be a rash individual who predicted the final outcome of this, the Marconi Company's latest development in wireless transmission; it may mark an epoch in the history of telegraphic communication. E. H. S.

TWO LOADED PHANTOM CIRCUITS IN A FOUR-WIRE SUBMARINE CABLE.

By J. G. Hill.

It is well known that a loaded phantom circuit can be superimposed on two loaded loops in a 4-wire submarine cable, and this is often done nowadays. In theory, it has also long been known that by working over the four wires in parallel to earth, an additional circuit can be obtained. Indeed, this idea was embodied in Mr. F. Jacob's English Patent Specification, No. 231, 1882. It was, however, pointed out by the discoverer that owing to inductive influences, etc., "it is generally preferred not to use the earth for telephonic purposes, this circuit nevertheless being available for working electric bells and other signals." As a matter of fact, the 4-wire earthed phantom telephone circuit does not seem to have been used up to the present in a commercial manner. Owing, however, largely to improvements in modern telephony, its use now appears to be practicable, although the scope of application is limited. The two main factors which have enhanced its value are, firstly, loading, and secondly, the fact that efficient transformers are now available. This was formerly not the case.

In examining the problem in connection with the 4-wire superimposed loaded submarine cables owned by the Post Office, the writer noticed that if the four wires were used in parallel to form a second phantom circuit this circuit is automatically loaded without the addition of other loading coils. Knowing also that such cables possess the advantage that their electrical condition is perfectly steady in the absence of faults, and that inductive disturbances from one submarine cable to another are generally negligible, except when interference occurs in cable huts owing to imperfect earths, the writer proposed experiments which have been attended with some measure of success.

1 shows the conditions required for loading the second phantom. Separate coils must be provided for the phantom circuit in each of the two side circuits. This is always done in the cables (which are loaded for the purpose of providing only one phantom circuit and two side circuits) manufactured by Messrs. Siemens, Bros. & Co., London, and used by the Post Office. The arrows in **1** indicate that in the case of the side circuit coil the current must circulate in opposite directions round the two sides of the coil to make it inductive, *i.e.*, to "load," whereas in the case of the phantom circuit they must travel in the same direction in any given side circuit. This condition is fulfilled in the case of both phantom coils in the 4-wire phantom, as all the currents are in parallel and the two phantom coils are independent of each other. The circuit is therefore loaded. A continuously loaded cable is, of course, also loaded if similarly used.

2 shows two alternative methods of connection, one at each end of the circuit, for convenience of illustration. Starting from the left with the earthed circuit 4 *E*, a current generated in 4 would split at the middle points of the transformers *C*, *A*, and *B*, and would therefore not affect them; it would unite at *F* after passing through transformers *D* and *E* in a non-inductive direction, but would find earth at *Ea* and complete its circuit, energising transformer 4*a* in the second phantom circuit. The apparatus on the right is a modification of that on the left, designed to minimise overhearing if it exists. Any overhearing currents from a side circuit to the earthed phantom must pass through one of the impedances *D F* or *E F*. Currents from 4*a*, however, pass through *D E F* non-inductively from *F*; it will be observed that *D E*, *E F*, are arranged with respect to the first phantom circuit on the lines of the Wheatstone Bridge. As shown in **2**, four separate land lines are provided. In theory three are sufficient, but there are numerous cases where the aërial lines are too long, or the conditions too difficult, to permit of a stable superimposed balance being obtained in the aërial section. Indeed, to ensure reliable and stable working four separate land circuits are to be preferred. Where suitable conditions exist, three land lines, as in **3**, may be provided. It is, however, absolutely essential that all direct connection between the land lines and the cable be avoided. If this is done, the currents shown by arrow heads, and induced in the aërial telephone loops by extraneous sources of disturbance (*i.e.*, telegraphs, power circuits, etc.) are annulled at the centre point of the transformers on the land side. If there were metallic connection between the aërial lines and the cable this would not be the case, but, on the contrary, the induced currents, passing in parallel over the cable wires, would disturb the earthed circuit, and probably render it unworkable.

It should be noted that the characteristic impedance of the

4-wire earthed circuit is only about one eighth of that of a 2-wire loop, so that a unity ratio transformer could hardly be expected to

Fig: 1.

Arrangement of Loading Coils

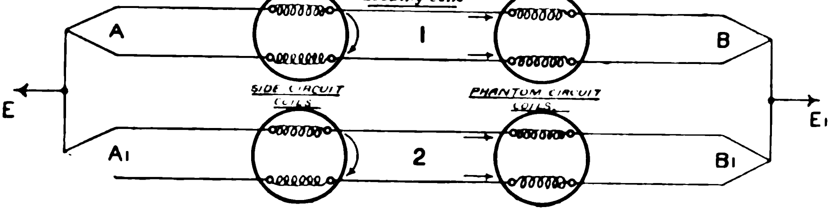


Fig: 2.

Two Phantom Circuits in Cable
(Land Lines not Phantomed.)

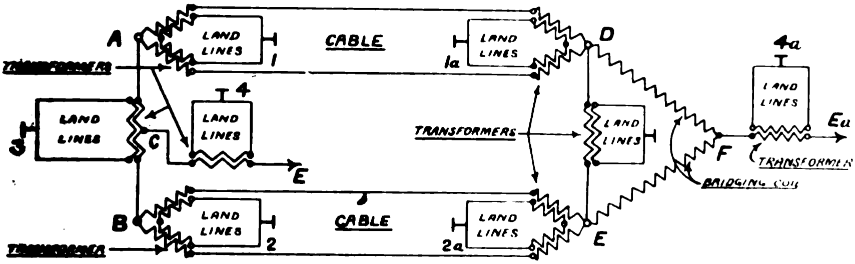
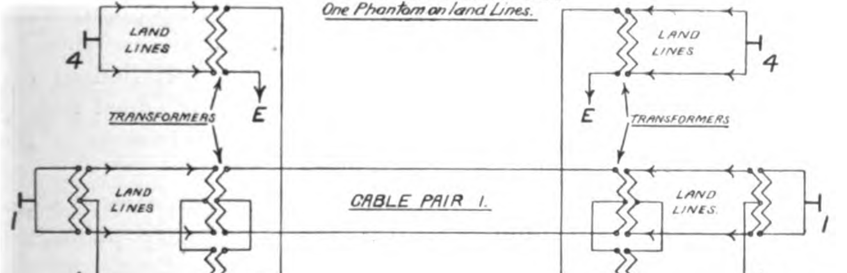


Fig: 3.

Two Phantom Circuits in Cable
One Phantom on land Lines.



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THEORETICAL ARRANGEMENTS FOR OBTAINING TWO PHANTOM CIRCUITS IN A FOUR-WIRE CABLE.

give the best results. If, however, such a transformer have two equal windings connected in series on the land side, and two similar windings in parallel on the cable side of the 4-wire phantom, matters are materially improved. The transformers used in some recent experiments were the Western Electric Co.'s type "4006A," designed by this Company but wound to a Post Office specification framed by Mr. S. A. Pollock, to give a good electrical balance in phantom working. This apparatus gives excellent results for speaking, ringing, and balance. The speaking efficiency of an earthed circuit is not quite so great as that of a loop circuit in the same cable. Experiments conducted by the Post Office have shown that the effective resistance of an earthed circuit in a submarine cable varies with frequency, and is higher than that of a loop circuit. At a frequency of 800 cycles per second, the increase was found to be of the order of 20 per cent. This is probably due to the cable sheath. Experiments have been made with two phantom circuits in both coil, and continuously loaded, cables, and promising results obtained. Some circuits are at present being worked on this principle. It should not be overlooked that phantom working involves some transmission loss on the side circuits in any case (say two standard miles), but the second phantom does not increase this loss. Quite apart, however, from the success of the present experiments, there can be little doubt that the material increase in the capacity of a 4-wire cable, which is given by an extra channel of communication in it, will concentrate attention on the desirability of still further improving the electrical balance in superimposed loaded cables, and thereby accelerating the already great progress which has been made in such cables in recent years.

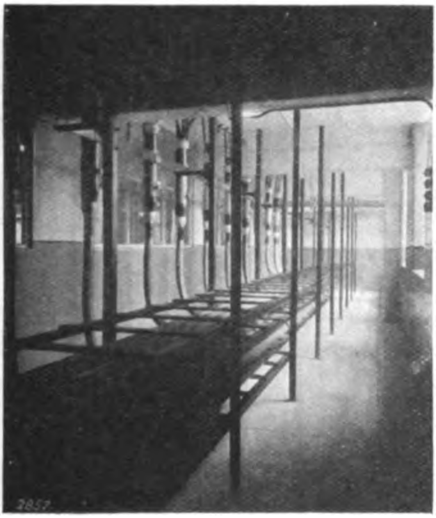
The fact that an extra loaded phantom circuit can be obtained without further loading coils suggests that if each separate wire could be loaded with one coil of suitable efficiency, then phantoming would not involve *additional* coils; but, alas, in that case there is danger of unequal "ageing" of the iron and of variation of impedance and efficiency in the *A* and *B* lines, with added risk of crosstalk, etc. It will be interesting to watch the behaviour of the two phantoms previously described in this respect.

The earthed phantom circuit also presents an alternative to the usual method of providing a third circuit (ordinary phantom). On this plan one pair would be loaded as a side circuit only in the usual accepted manner, the other pair being loaded for side and phantom working, either in the ordinary manner or by a single coil in each wire, the phantom circuit being worked over this pair in parallel to earth. The single coil method is the more efficient, and if, as assumed, one pair is well balanced, there should be no cross talk from side to side in any case. There would, however, be greater risk of unbalance between the phantom and its side than if single coils were not used. Transformers would be necessary in *both* side circuits to isolate the land lines.

LEADING IN MAIN CABLES AT EXCHANGES.

By J. M. Shackleton.

The methods adopted for leading in main cables at telephone exchanges so as to bring them from the street ducts to the main frame in an orderly and economical manner differ somewhat in accordance with the varying conditions of the building or the site, but this is a matter in which forethought and careful planning are well repaid by subsequent good results, and on the other hand the absence of foresight is likely to cause serious difficulty and also a congested and unsightly cable chamber.



I.—Victoria Exchange Cable Chamber, showing part of Cable Rack. Note Solid Joints connecting 800-pair Cables to Four 200-pair Cables leading to M.D.F.

Designs for leading in should be arranged so that:

(1) No difficulty will be experienced in handling the cables up to the time that the exchange reaches its ultimate capacity.

(2) Each cable will take its correct duct in the street manholes and awkward crosses in the manholes avoided.

(3) Any cable may easily be taken to any particular portion of the main frame in a workmanlike manner.

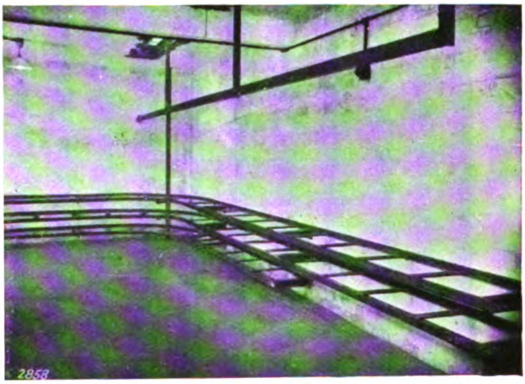
(4) The length of silk and cotton covered cable should be a minimum.

(5) The joints between the paper core and the silk and cotton covered cable can be made in positions that are convenient for working.

1 gives a view of a portion of the leading-in arrangements at the new Victoria Exchange, London, which was opened on January 24th, 1914, and it is thought that all the considerations as set forth above have been fulfilled in this case. Owing to the nature of the chamber it was somewhat difficult to obtain a good picture, but the general design will be fairly evident from the photograph.

The test room at Victoria is on the ground floor, and the silk and cotton covered cables can be seen as they enter the short floor-ducts, which are placed immediately under the main distributing frame.

The "Victoria pattern" cable rack is being adopted at other new exchanges in the London Engineering District, suitable modifications being made when the test rooms are placed on upper floors.



2.—Greenwich Exchange Cable Chamber, showing Cable Rack. Note Horizontal Bar to which Potheads are to be Fastened.

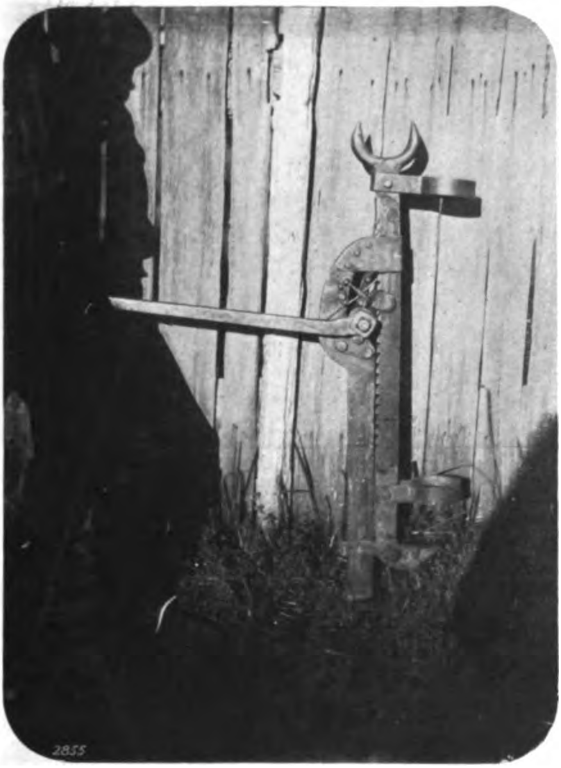
In the smaller exchanges, where only few cables are required, the "Greenwich pattern" rack is being adopted. In this design, the framework is carried on stanchions which are fastened to the walls; otherwise, the main features of the "Victoria pattern" are preserved.

2 shows a view of one of these racks in course of completion prior to any cables being led in.

Careful calculations as to the ultimate number of cables required should always be made before the design for leading in is put in hand, and even in the case of small exchanges a working drawing showing full details should be prepared so that the foreman blacksmith knows exactly what to do and nothing is left to chance.

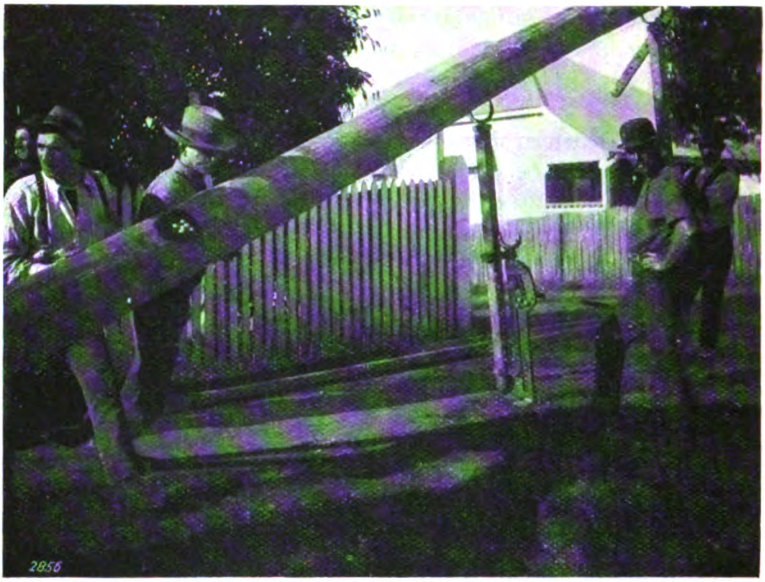
AN AUSTRALIAN LIFTING JACK FOR ERECTING POLES.

THE accompanying photographs illustrate a pole-lifting device which has proved of considerable utility in Queensland, and which is now being introduced into the other States of the Australian Commonwealth. The jack itself (locally known as the "Wallaby" jack) is shown in plate 1, in which it is shown with a steel prong or fork slightly raised. By means of its use the number of men required to erect a long or heavy pole is greatly reduced. The pole is raised by means of lifting or levering into a position which admits of the prong of the jack being inserted there-under. One man then suffices to work the jack, and the pole is lifted by means of the jack arm. The weight of the pole is then taken by a short pike or dead-man; the jack can then be released and the movable arm lowered, and a pike of suitable length fitted into the holders which it carries. The method adopted is clearly shown in plate 2.



1.—THE "WALLABY" JACK.

The operation of the jack has been found to be safe and effective. The device has certainly justified itself as a labour-saving one, and its extension to the other States after a lengthy experimental trial in Queensland has now been decided upon.



2.—Raising a Pole with the "Wallaby" Jack.

THE TESTING OF ELECTRIC LIFTS.

By "Tom Redcam."

Although the Post Office lift specifications definitely lay down particular tests which are to be carried out upon the installation of a lift, there are many other points which should receive attention before it can be pronounced as satisfactory. Of course, the principal points to be considered are those which affect the safety of the passengers, and it is proposed therefore to deal with these first.

Safety Gear.—In a number of cases it will be found that this gear is operated by means of a small steel "fly" rope, which pulls the gear into action if more than a certain stress is put upon it. In such a case the best method is to haul up the cage, by the means of lifting tackle, a distance of 18 in. or 2 ft. In doing this the steel suspending ropes will be slackened, and also the fly rope. The latter should then be tightened so that it is as taut as it usually is when the lift is in full operation. This can either be done by the means of adjustment usually provided, or by wrapping a bight of the rope round a piece of wood and securing it there with string. The top set of pulleys of the tackle should be secured to a wooden beam, which may have one end resting on a landing floor, and the other on one of the straps across the balance-weight guides. If this cannot be arranged, the fixing may be made to one of the joists, which support the overhead sheaves or the winding engine, or to the steel suspending ropes. In the latter case the slack portion of the ropes is left between the point of fixing and the top of the cage. The tackle should depend on a single piece of rope for preference, which can be completely severed at one blow.

The cage having previously been filled with weights to the extent of its full load and the above preparations made, its position should be accurately marked on the side of the lift-well or on the side of one of the lift-well entrances. The rope which supports the tackle, etc., ought then to be cut through by a smart blow with a carpenter's chisel and mallet, when the cage will fall and be brought to rest by means of the safety gear, if all goes well. The distance the cage has fallen should then be measured and recorded. It should not exceed 1 ft., and is generally considerably under this.

Some contractors prefer to test the gear with no load in the cage, arguing that this will indicate whether there is any chance of the safety cams not gripping properly. The cams are so constructed that directly they touch the guide backings the weight of the cage, etc., tends to force them into closer contact with the backings, and reliance is placed on this action more than on anything else, so that there is some reason in this contention. But it must be borne in mind that with full load in the cage the test is far more severe, and leaves no doubt as to the strength of the materials employed in constructing the cage and safety gear, etc. If there is any doubt about the matter there should be no hesitation in carrying out the test in both manners.

With the exception that the load cannot be altered the above remarks apply to the balance-weight safety gear also.

In some types of gear a fly rope is not employed, the cams being brought into action by the slackening of one or all of the suspending ropes, allowing springs to produce the desired result. In such cases it is not possible to suspend the cage conveniently by means of tackle, and the only thing that can be done, therefore, is to run the cage on the downward journey, and to pull the cams into action while travelling at full speed. This is not an entirely satisfactory method, but it certainly tests the strength of the apparatus and also makes sure that the safety gear is working freely.

ROPES.—Not much need be said with regard to the tests carried out on these when the lift has been installed. The Post Office specification is quite clear on this point. It may be stated, however, that the cage should be stopped about a foot above the lowest landing and its position marked. Standard weights equal to the weight of the cage plus twice the specified load should then be placed in the cage. The actual weight on the ropes will then be twice the full load plus twice the weight of the cage, and the position of the cage should again be marked. The weights are left for half-an-hour, the position of the cage then noted, and the weights removed. The point to which the cage returns must then be ascertained. It is probable that in no case will the temporary stretch exceed two inches, and it is not likely that it will be nearly as much. As a general rule, the cage finally returns to within half-an-inch of its original position.

CURRENT CONSUMPTION.—In placing an order for a lift, consideration is given to the energy consumption which the contractor guarantees will not be exceeded. This figure includes the energy consumed by the motor and controller in performing a complete "up" and "down" journey with full load in the cage. It is important, therefore, that the actual consumption should be measured, and for this purpose integrating wattmeters for both direct and alternating current are provided by the Department. Sometimes it happens that these instruments are not available at the moment they are required, and in these circumstances reasonably reliable tests can be made by using the Supply Authority's meter. Of course, care must be taken that all other loads on the meter are switched off. In either case the best plan is to run the lift up and down ten times with full load in the cage, the resulting reading on the wattmeter being divided by ten in order to obtain the desired figure.

If the controller and motor are connected to entirely different circuits, two sets of runs must be taken with the meter inserted in either circuit as required. It is not uncommon to find that the energy taken by the controller is not sufficient to cause an *integrating* wattmeter to register, in which case all that is necessary is to take ammeter and voltmeter readings, or to use a wattmeter, and to multiply the resulting readings by the time taken to perform a complete journey. The latter figure can be easily obtained by means of a stop-watch.

RUN CURVES.—These should be taken on a recording ammeter, and are very useful in obtaining proper adjustment of the controller. Inspection of the curves will reveal whether current is applied unsteadily, in excessively large steps or too slowly, and the setting of the controller should be altered accordingly. Proper attention to these points will enable the current consumption to be reduced to a minimum. Curves should be taken when the lift is working with the cage empty, with half load and full load. The "half load" curves for the "up" and "down" journey should be almost exactly alike. If they are not, then the cage is not properly balanced. An "up" curve being smaller than that for the "down" journey would indicate that the balance weight is too heavy, and *vice versâ*. When the lift has attained its full speed, the curve should be flat. If any sudden rise is shown, the probabilities are that either the cage or balance weight is sticking on its guides somewhere, or there may be something wrong with the winding gear.

SWITCHING DEVICES.—Under this heading is included the controller, car switch, and push-buttons, etc. The tests are quite simple, but are none the less necessary, the object largely being to ascertain whether their arrangement is quite "foolproof." All that is required, then, is to start the lift in the usual manner and operate any of the other buttons, etc., there may be. There should be no possibility of stopping the lift, except by the proper means, or of interfering with it in any other way. It should, furthermore, be ascertained that the lift will not start if any gate be open, and care should be taken to find whether the lift can be stopped by shaking a gate in such a manner as to break the circuit at the gate contacts. There should be no doubt that when the gates are properly locked the contacts cannot be interrupted by any such means.

Another test that should be made is to start and stop the lift every fifteen seconds, repeating this for some minutes, and then feel the various contacts on the controller to ascertain whether there is any undue rise of temperature at these parts. It saves time to arrange for this to be done when running the lift to ascertain the energy consumption.

The control limit switches can be tested by running the cage to the top and bottom of its travel and noting the distances past the top and bottom landing at which the cage stops. There are still the ultimate main limit and the slack cable switches to be tried, and these can best be actuated by short-circuiting the control limit switches for the former test, and in order to test the slack cable switches, which are only fitted where a drum drive is used, the cage can be wound up by hand until the balance-weight lands on its buffers, and *vice versâ*. This procedure causes the ropes first on the balance-weight and then on the cage side to become slack, and it can thus be found whether these particular switches operate properly.

The above constitutes all that may be properly described as "Testing," the other points requiring attention falling under the head of "Inspection." This important duty does not come within the scope of such an article as this, and, in fact, requires no description. All that is necessary is a copy of the specification and—"gumption."

EXAMINATION HUMOURS.

By And. Fraser.

Somewhere in his essay on philosophy, Sydney Smith defines laughter as being the result of a perception of incongruity. If we accept this definition, the following extracts from actual examination papers should leave the reader in a pleasantly mirthful condition, for they certainly possess the power of creating that necessary quality.

The remarkable productions which we shall give have been furnished by candidates in a recent examination, and although the field covered is a somewhat restricted one it is yet amply sufficient to enable the unconscious humorist to freely disport himself. Many of the answers, it will be seen, have been imperfectly memorised from text-books, with the result that unconnected fragments coalesce with startling results. Some of the answers submitted give evidence of a lurking idea struggling with the difficulties of expression in the process of materialising itself. Others again betray no such conflict. Right or wrong, pertinent or otherwise, the idea, such as it is, is there; and simultaneously with it, is its form of expression; the two being absolutely welded together. As an instance of the latter, take the case of the candidate—a Hibernian—who, in answer to the question as to how a double-current duplex set should be joined up, replied, "See the official diagram book." The instance is one on all fours with that of the candidate at an examination for the Excise who, in answer to the question, "Name the principal towns on the East Coast route," replied "See Bradshaw's guide."

After such a promising start, it was fitting that the same candidate should follow it up in answering a question on the measurement of conductor resistance with the Wheatstone Bridge, by protesting that in all his twenty-five years' experience of testing duties, he had "never yet been required to do such a thing"! However, he evidently felt sufficiently at home in the mysteries of the old morning test (Eden's) to confidently state that the object of the two 10,000$^{\omega}$ blocks was to reduce the strength of the current so as to bring it within the fine division portion of the tangent galvanometer scale! Little wonder that the "tangent" is fast disappearing from our offices; no self-respecting galvanometer would survive such a thing.

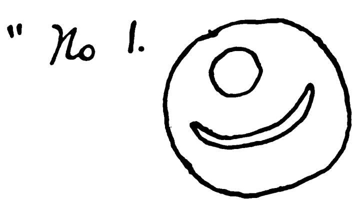
Verbosity is the great weapon of the unprepared candidate, however; by its means he hopes to convey the impression that if there is one thing more than another with which he is supremely *au fait*, it is the subject matter of the question he is dealing with. The following as an instance would be hard to beat:

The question was, to sketch and describe an ammeter and to show how it could be used as a voltmeter.

Answer: An ammeter is an arrangement fitted to suitably shaped apparatus, whereby coils are adjusted so as to offer a standard indication of the strength in voltage of a current passed through its divisional sections and reflect its record by the movements of a needle in front of a set of fixed readings. Thus if a + or — current of 80 volts is passed through it, it will indicate the correctness or otherwise of the current in volts.

As illustrative of his description, he begins with a diagram of a 6 terminal two-position switch. Finding that this does not quite meet the case, he rubs out and replaces it with a diagram of Euclid III, 20, with an auxiliary circle which, with its internal markings, might be representative of one of Prof. Boys' soap bubbles, or a miniature solar halo.

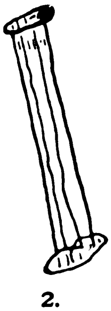
Another candidate, who attempted this same question, was determined not to commit himself to anything written. After weighing the whole thing carefully up he at length produced the following:



1.

There, the reader has the alpha and the omega of the entire matter. Are words, with their limitations, needed where such an orb smiles serenely down upon us? Certainly not; one stroke more would destroy the calm serenity of that significant countenance. The official wag, on being shown the result, facetiously remarked that "the thing would be all right if it had its teeth in"!

Candidates, as a rule, are fairly proficient in the matter of sketching telephone transmitters and receivers, but the following,



2.

which is a sketch and description of the solid back transmitter, will doubtless suggest a new train of ideas in the minds of those of our colleagues who are thinking out a transmitter that will speak through 100 miles of "standard" cable without the aid of a Brown relay! Let the humorist speak for himself: "This transmitter is fitted with two magnets which, I believe, is not usual in the other kinds."

As it stands the structure might be anything from a glass fuse to the mast of a wireless aerial, but, whatever it is, we leave this solid back transmitter with its two magnets and inherent potentialities and pass on to other things.

(*To be continued.*)

THE ANNUAL AGREEMENT AS AN OBSTACLE TO DEVELOPMENT.

By JOHN H. WHITEMAN
(Glasgow Telephone Service.)

DEVELOPMENT study in relation to the telephone service must be an interesting occupation, but the conditions under which it is carried on may possibly have a tendency to limit the outlook of those engaged in it, and it is conceivable that in this, as in other things, the onlooker may see most of the game. That is the only excuse I have to offer for venturing to make a few observations on a subject which may be claimed as one reserved exclusively for the expert.

The Engineering Department takes up the matter from its point of view; the Commercial Department does the same. They compare notes and agree on a conclusion. They have to deal with existing conditions, and, in the circumstances, no doubt the procedure is the best that could be adopted. No criticism need be offered on this aspect of the question, but the outsider may be pardoned for attempting to direct attention to other factors, especially at this particular time when, no doubt, the larger questions of rates and general policy are being discussed.

Public opinion is not clearly articulate on the telephone question, but it must be reckoned with, and, so far as it has expressed itself, there can be no doubt that it is to the effect that there must be a cheap telephone service—and plenty of it.

It may be urged—and it would be difficult to dispute the contention—that if the price is made low enough the demand is likely to exceed the supply for several years to come. But the price must be based upon the cost, and it may therefore be found that it cannot be fixed low enough to please the public.

Having arrived at this point, which I take it is exactly the position to-day, it seems to be assumed that the only course to follow is to persuade the public, by personal interviews or other forms of advertisement, to become telephone users. This can be done only at very great expense, and is, of course, a considerable factor in the cost of the service. No doubt a very creditable record of expansion can be pointed to in support of the principle of canvassing, but conditions have been changing rapidly in the last few years, and there is no longer so much need as formerly to persuade people that the telephone service is a desirable thing to have at their disposal. The energies of the contract force are mainly directed towards inducing people to enter into a legal and binding agreement to pay their Telephone subscription yearly in advance. If the latter condition were abolished those energies could be much more usefully applied in educating the public in the utilisation of the service to its fullest possible extent.

Monthly terms of payment have been adopted apparently successfully in other countries, and the adoption of that system may be in contemplation in the United Kingdom. In any case it is a reasonable proposition, for it must be recognised that the payment of yearly subscriptions in advance is one of the greatest obstacles to rapid development.

The point I wish to urge, therefore, is that the work of the contract officer largely consists of overcoming the objections to this system of payment. If it is admitted that a system of monthly payments is desirable and practicable, the logical conclusion is that agreements in their present form are no longer necessary.

It may be argued that a formal agreement is necessary, in order that the conditions under which the service is provided may be defined. Those conditions, as they are at present, or as they may from time to time be modified, need not be discussed here, but whatever they are or may be they could quite well be defined without being embodied in the agreement form. A simple application would then be all that would be necessary, and the following form is suggested for consideration :

" The undersigned
" desires to avail himself of the telephone facilities and services
" provided by the Postmaster-General, subject to the provisions
" and conditions herein and in the schedule which may be seen
" at any post office, and agrees to pay monthly in advance for
" such services as he may require.
" Signature
" Address
" Date ."

The first thing that will occur to those who have been for a long time connected with the telephone service, under either form of administration, is that the adoption of such a proposal would have far-reaching effects on the organisation, not only on the contract but also on the revenue-collecting branches. That is precisely the intention of the proposal, and I am reluctant to believe that the Departmental accounting experts would admit that the difficulties arising out of it are insuperable. On the other hand, if there are any arguments to be advanced against it, it would be interesting to know what they are.

To canvass a business man has the effect of immediately putting him on the defensive. His brain is stimulated to produce reasons for not buying the article which the other man is anxious to sell, and the ultimate issue depends more on the personalities of the respective parties to the transaction than on the practical aspects of the proposal.

The question resolves itself, after all, into one of service. If the service is good enough, it will attract all to whom the service can possibly be of use provided no artificial obstacles are placed in their way. If the service is not good enough to do that, not all the blandishments of all the most polished orators will ever convince subscribers that they are getting what they are paying for.

EDITORIAL NOTES AND COMMENTS.

THE ADVANCE OF THE AUTOMATIC EXCHANGE.

FOR the third year in succession we present our readers in this number with a description of a new automatic exchange equipment. In Part 2, Volume V, there appeared a detailed account of the Automatic Telephone Manufacturing Company's system installed at Epsom; in Part 2, Volume VI, the Lorimer Company's installation at Hereford; and now we give the Western Electric Company's Darlington Exchange.

From a purely maintenance point of view the introduction of a number of diverse systems means the stocking of many parts for replacement purposes, and in the initial stages these parts have to be purchased in small quantities, and consequently at relatively high prices. The three systems mentioned above do not complete the list, as contracts have been placed with Messrs. Siemens Brothers for two exchanges and three traffic distribution schemes, which we hope to be able to describe in a future number of the JOURNAL. The claims of the various schemes are such that only practical experience of their working can determine the system, or systems, best fitted to survive. There can be no doubt that the mechanism of the automatic exchange can be constructed in various ways to function properly and to give a reliable service, but it will be a long time yet before the occupation of the telephone girl has gone. The development and present operation of the telephone system in this country, trunks and junction lines, phonogram circuits, coin-box subscribers and party lines, render it necessary that manual positions should be installed even in new exchanges that are termed full automatic. Hence it is that in a direct comparison of costs between a standard C.B. manual and an automatic equipment, the latter is saddled with the capital cost of quite a number of manual positions, and standing charges for operators' wages, the deletion of which, the largest item on the annual bill, is one of the main claims of the automatic plant. By the very circumstances of the case, therefore, the later entrant into the field has to compete with a considerable handicap. This may be one of the reasons why the American Telegraph and Telephone Company has, so far, hesitated to embark on a policy of conversion in the United States, and has left the introduction of the public automatic exchange to the independent companies.

In this country the arrival of the automatic system has been opportune. For obvious reasons, the late National Telephone Company pursued for the last few years of its life a policy of masterly inactivity—we hope we do not offend our zealous transferred colleagues by this description of the action of the Company—with the result that a large number of exchanges had reached the stage of obsolescence; the Department had to consider the system to supersede the magneto, the call-key, the ring-through, and other types of exchanges which had lingered beyond their time. Immediately prior to, and during the transfer period, accommodation had to be provided for the subscribers connected to the condemned exchanges and to exchanges whose leases were expiring, and since the time-limit was the main factor manual equipments had perforce to be installed. Now, however, that the manufacturers have laid down plant capable of producing automatic apparatus on a large scale, not only in America and on the Continent, but in this country, the C.B. manual exchange will have to fight for its existence.

It should be stated that not a few well-known telephone engineers —uninfluenced by the correspondent in the *Daily Mail*, who recently declared that the automatic system was but an inventor's dream, and abandoned as such years ago in America—are convinced that the manual system will more than hold its own, and several proposals have been made to enable this system to meet conditions now fulfilled by the automatic equipments. The question is mainly an economic one—influenced to a certain extent by our climatic conditions and by the temperament of the public owners and users of the telephones, and there is not sufficient data available to prejudge the case.

As Mr. B. O. Anson, of the Engineer-in-Chief's Office, pointed out in his paper read before the Traffic Authorities' Conference on May 7th, the introduction of automatic telephony is a world-wide movement, and there is scarcely a civilised country in which it is not making headway. We give elsewhere in the JOURNAL an account by the Engineer-in-Chief of the Austria-Hungary Telephone Administration of the progress being made in Vienna and elsewhere in the country. In Germany some 25 full or semi-automatic exchanges are working or being installed; in France, 4 exchanges; in Holland, 5; in Italy, 3; in Canada, 10; in Australasia, 14; and in the United States, 70. The following list gives the position of affairs as regards this country:

Exchange.	Lines.	Position to date.	Contractors.
Epsom . . .	500	Exchange working	Automatic Telephone Manufacturing Co.
Offl. switch . .	650	,, ,,	,,
Hereford . .	500	,, ,,	Lorimer Co.
Darlington . .	800	To be opened in a few days	Western Electric Co.
Newport . .	1900	Plant being constructed or now being installed	A. T. M. Co.
Portsmouth . .	5000	,,	,,
Accrington . .	700	,,	,,
Paisley . . .	1100	,,	,
Leeds . . .	6800	,,	,,
Chepstow . .	65	,,	,,
Grimsby . .	1300	,,	Siemens Bros.
Stockport . .	950	,,	,,
Dudley . . .	500	,,	Western Electric Co.
Paddington, Traffic Distributor	1000	,,	Siemens Bros.
Split I/C O.W. Central	1 pos.	,,	,,
O G. O.W. Selector Central	10 ccts.	,,	,,

In addition to the foregoing, proposals are in hand for the installation of a semi-automatic exchange for 6000 lines at Liverpool to replace Liverpool Central, and a full automatic equipment at Blackburn. The latter scheme is of considerable interest, inasmuch as Blackburn is in the same telephone area as Accrington and the subscribers on the two exchanges will be allotted two adjacent blocks of numbers. Subscribers on the two exchanges will call each other direct, instead of dialling for a manual operator as is the practice on the automatic exchanges now in operation. The extension of this principle, together with the provision of a sufficient number of junction circuits to give a no-delay service between contiguous towns having a considerable volume of traffic, will diminish appreciably the number of manual positions required, and gives promise of a service much in advance of anything yet provided.

Chepstow is another interesting experiment. Although it is admitted that an automatic system can be provided most economically on a large scale, the practicability of installing an automatic plant in place of the village manual exchange giving an all-night service is one that must be hailed with relief by the authorities. In the excompany's days, exchanges of this type were—and are still in many cases—fitted in private houses, and a resident caretaker looked after the evening and night calls. The transference of the exchange to the local post office has brought with it many worries to the administration, owing to late-fee charges and to complaints produced by false and unpursued calls during the night. An arrangement that enables local calls to be completed, and long-distance calls to be transmitted to the nearest exchange where a night operator is employed, without disturbing the slumbers of the hard-working local postmaster, is one that deserves a fair trial, even although the initial cost may at first sight appear almost prohibitive.

The Station List.

We had hoped to be in a position to supply our readers this issue with a second instalment of the station list, following on with the engineering officers below the rank of assistant engineer. The work of allocating the correct seniority of these officers has, however, not yet been completed, and in consequence the publication of the second instalment has been deferred. Should this list not be available in time for our next issue, we propose to supply in its place an up-to-date list of the clerical members of the staff eligible for membership of the Institution.

HEADQUARTERS NOTES.

Conference of Superintending Engineers.

Mr. Slingo, the Engineer-in-Chief of the Post Office, held his Second Conference of Superintending Engineers at Southport from May 5th to 8th last. The previous similar Conference was held in the same month of last year; an account of the proceedings at that Conference and a portrait of the members were published in our issue of July last. The agenda was a somewhat formidable one and readily accounts for the inability (as in 1913) of the members of the Conference to visit manufacturers' works, etc., during the Conference week—a practice which obtained in connection with previous conferences—as well as for the comparative rapidity with which the 1914 Conference followed its immediate predecessor. This year's Conference was of even greater importance than last year's, and this fact was made abundantly clear in the Engineer-in-Chief's opening address. The work which had faced the Superintending Engineers during the last year, he stated, was the carrying out of an unprecedented programme of construction, etc., work, and he congratulated them on the result of their efforts. The ascertained expenditure was £5,714,000 or £8,000 more than had been anticipated. The estimated engineering expenditure for the present financial year was £8,151,000, or 40 per cent. increase over that of the previous year.

Much consideration was given to organisation and staff questions, and no less than twenty-three out of the fifty items on the agenda related to such subjects. In the course of the discussion on these matters, the Engineer-in-Chief announced that the staff of the Engineering Department had increased within the last two and a half years from 9,000 to 24,000.

Conferences of this nature are, undoubtedly, of great value and among the many advantages arising therefrom is the opportunity afforded the Engineer-in-Chief to place his views on various subjects before his district officers personally and collectively. The fullest advantage was apparently taken of this opportunity at the conference held in May last, for it is the unanimous opinion of all those present that the instructive character of Mr. Slingo's remarks was the outstanding feature of the gathering.

Since the last issue of the JOURNAL orders have been placed for the equipment of new C.B. Exchanges at—

Darwen	520 lines
Devonport	760 ,,

and for extending the existing equipment at—

Bristol	1460 ,,
Derby	360 ,,
Victoria (London)	1600 ,,
Worthing	300 ,,

Installation has been commenced at—

Greenwich New Exchange	1600 ,,
Weybridge ,, ,,	680 ,,
Dublin Extension	1080 ,,

Installation of the following equipments has been completed:

Museum New Exchange	9720 lines
Purley ,, ,,	1200 ,,
War Office P.B. Exchange	500 ,,
Altrincham Extension	300 ,,
Birmingham (Victoria) Extension	140 lines
Kensington Extension	3310 ,,
Manchester City	1300 ,,
North Shields	300 ,,
Shipley	180 ,,
Worcester	320 ,,

LONDON DISTRICT NOTES.

New Buildings in Progress.

The work in connection with the new offices of the London Engineering District to be erected on a site at Denman Street, London Bridge, adjoining the existing offices, has been commenced, but did not proceed very far before it was held up by the strike of London builders. The excavation of the foundations had been completed.

New Exchanges.

The opening of the Museum Exchange took place on April 20th. As the name suggests, this exchange serves the District in the neighbourhood of the British Museum. It will relieve to some extent the existing pressure on Central, City, Gerrard, Mayfair, Regent, North, and Holborn Exchanges. Equipment has been provided for 9720 direct lines: the switch-room includes—

113 "A" positions,
2 testing operators' positions,
2 electrophone positions,
1 plugging-up position,
together with
43 "B" positions, and a
10-position information desk.

The building has been specially erected for an exchange, and is, so far as the site would allow, similar to that recently opened at Victoria. The equipment was fitted by the Automatic Telephone Manufacturing Co., and is of the No. 1 Common Battery (22-volt) type.

A new building to accommodate an exchange at Greenwich has been completed, and the installation of 1500 lines is proceeding. Messrs. Peel-Conner Telephone Manufacturing Co., Ltd., are the contractors, and the equipment will be of the No. 1 Common Battery (40-volt) type.

Exchange Extensions.

Hampstead.—The extension of the multiple to the extent of 900 lines will shortly be commenced at Hampstead.

North.—A rearrangement of the building has been carried out, and an extension which will provide 1000 additional lines is in progress.

PRIVATE BRANCH EXCHANGES.

The largest work under this head at present in progress is the provision of a new exchange for the War Office. It will include eight positions, and the installation is being carried out by the British L.M. Ericsson Co. Immediate provision is being made for 500 lines, with an ultimate capacity for 800 lines.

Selfridge's private branch exchange is being increased from six positions to nine positions.

Three-position switchboards have recently been fitted for Messrs. Shoolbred, Tottenham Court Road, and for the London General Omnibus Co.

A two-position Private Branch Exchange has recently been completed at the offices of the South Metropolitan Gas Company, in the Old Kent Road. The installation consists of twenty Exchange lines, eighty extensions, and ten private wires fitted with long-distance equipments. This installation replaces two 50-line magneto pattern switchboards. A considerable amount of traffic exists from certain lines fitted between the chief offices and the show-rooms in the various South London suburbs, and a novel feature in connection with these lines is an arrangement for indicating in the main offices at Old Kent Road when these show-room lines are engaged. This arrangement saves the time of both the office staff and the operators.

The arrangement consists of keys fitted in the switchroom, which, when depressed, produce signals in the offices. A key and signal is fitted in connection with each show-room line. When a show-room line is engaged, the operator depresses the key, intimating that it is useless to make application for the line in question while the signal is showing. The keys are restored to normal when the line is disconnected.

NEW TELEPHONE LINES.

During the thirteen weeks ended April 28th, 1914:

5243 Exchange lines,
3343 Internal extensions, and
209 External extensions

were fitted.

In the same period:

3243 Exchange lines,
1899 Internal extensions, and
199 External extensions

were recovered, making a net increase of

2000 Direct lines,
1444 Internal extensions, and
10 External extensions.

EXCHANGE MAINTENANCE.

The repair of switchboard flexible cords is a very important feature of exchange maintenance, and the proper carrying out of this duty may greatly influence the working of an exchange. Repairs have hitherto been carried out in one of two ways:

(*a*) By withdrawing the cords from the switchboard and repairing them in a workshop, or

(*b*) By having a portable cord repair table, and carrying out the repairs at the switchboard.

Method (*a*) proved to be expensive, and method (*b*) was objectionable on account of the interference with the traffic, and could only be carried out satisfactorily at night.

Recently a London Engineer suggested that the cords might be passed through a hole in the front of the switchboard, and repaired during the day by youths working in the rear of the sections. This has been tried and found to be so successful and economical that it is now being standardised. Special arrangements are necessary to ensure that wire ends and clippings are not allowed to fall into the wiring at the rear of the sections.

UNDERGROUND TRUNK ROUTES.

The London Section of the following underground trunk routes has been completed:

London–Canterbury. $\frac{1600}{150} MT + \frac{48}{100} MT + \frac{84}{70} MT + \frac{10}{40} T$, loaded.

London–Slough. $\frac{200}{70} MT$, loaded.

London–Weybridge–Guildford. $\frac{100}{70} MT + \frac{100}{40} MT$.

Underground trunk cables are in course of provision as follows:

London–Brighton. Work being carried out by Messrs. Johnson & Phillips. Approximately 2½ miles of 2-way duct have been laid.

London–Ware. $\frac{200}{70} MT$, loaded. 4½ miles of 3-way Sykes' ducts, 3½ miles of 4-way ducts, 1¾ miles of 6-way ducts, and ½ mile of 9-way ducts have been laid, and about 7½ miles of cable drawn in, up to June 1st.

The London–Birmingham $\frac{4}{300} MT + \frac{28}{200} MT + \frac{24}{150} MT + \frac{48}{100} MT$ is being laid by the Western Electric Company. An article describing the installation of this cable appeared in the last issue of the JOURNAL. The loading of the cable is in progress.

CENTRAL TELEGRAPH OFFICE.

The item of principal interest during the past three months has been the introduction of duplex working on various Baudot circuits, viz.:

London–Hamburg, now working double and triple duplex (providing six channels on one wire).

London–Emden, now working double duplex (four channels on one wire).

London–Liverpool, now working quadruple-duplex (providing eight channels on one wire).

A new circuit London–Leipzic, working on the Hughes duplex system, has also recently commenced working.

ANNUAL GATHERING.

The Second Annual Gathering of the London Engineering District, which took the form of a dinner, dance, and concert, was held at the Holborn Restaurant on April 4th. The Chair was occupied by Mr. A. Moir, Superintending Engineer, who, with Mrs. Moir, received the guests, to the number of 360, including Mr. and Mrs. Slingo, Mr. and Mrs. Noble, Mr. C. B. Clay, Mr. W. A. Valentine, and other representatives from various Departments of the Post Office.

In proposing the toast of "The London Engineering District," Mr. Slingo stated that it was a great privilege to belong to the London District, and commented on the fact that no other district in the country could get together such a fine assembly as was present that evening. He hoped that no subscribers of the London Telephone system were present, as, having regard to the prosperous appearance of the company, he feared that they might think that there was little prospect of any reduction in telephone rates. (Laughter.)

He referred to the amount of work that had been done during the past year, but stated that during the financial year which had just opened there would be something like 50 per cent. more to do than was accomplished in the previous year, and if the increase of staff only amounted to 5 per cent. it would be seen that each member would have to increase his output by 45 per cent. Mr. Slingo said everyone would be pleased to hear that they had "got to do" 45 per cent. more work. (Laughter.) He knew that they were prepared in their devotion to the Post Office to sacrifice another 45 per cent.

to the general welfare—perhaps. (Laughter.) He, however, was certain that everyone would endeavour to do all he could to maintain the credit of the London Engineering District. It was a very important part of the economy of the Engineering Department generally.

Mr. Slingo referred to the change which had recently taken place in connection with the minor staff. They would see soon—if they did not see it now—that everything had been done in their interest, and before long they would realise what a great advantage the scheme, which is now being put into operation, would be.

He concluded his remarks by saying that if the work was as well done in the future as it had been in the past the British Post Office would retain its proud position.

In replying to the toast, Mr. Moir stated that during the past year the District had been responsible for an expenditure of £1,113,000, including the cost of stores and payments to contractors; but he thought he was justified in assuring the Engineer-in-Chief that the money had been well spent. The mileage of the district had been increased by 98,000 miles, and 17,000 additional telephone stations had been brought into use. The latter figure indicated a quicker rate of telephonic development than was shown in previous years, and placed London—from the rate of development point of view—at the head of the European cities with over one million inhabitants.

He stated that a new 10,000-line exchange had just been opened successfully at Victoria, and that an exchange of similar size to be called Museum was about to be opened. Four additional exchanges of a similar size had been decided upon, as was announced by the Postmaster-General in the House of Commons, and active steps of a preliminary character were well in hand. These 10,000-line exchanges were the "Dreadnoughts" of the Telephone Service. In naval matters this country maintained its supremacy by adding to the Navy a certain number of first-class battleships every year, and if London was to maintain and improve its position as a telephoning city—as he felt sure it would—the speaker held that it would be necessary to open at least two capital exchanges of 10,000 lines every year, and also to provide extensions at existing exchanges where necessary.

Mr. Moir stated that the number of public complaints regarding the service had been sensibly diminished, and that the time taken to to join up subscribers' circuits was gradually being shortened. (Cheers.)

During the past year 565 additional men had been added to the staff of the District, bringing the total to well over 5000. He claimed that the London staff was both enthusiastic and patriotic. Without enthusiasm no man ever did very much, but in telephone matters enthusiasm was absolutely necessary. It manifested itself in several ways—particularly, perhaps, in the gentle rivalry which had been engendered between the various Sections of the District by means of comparative statistics. The patriotism of the staff was proved, he thought, by the fact that no fewer than 350 members belonged to the Territorial Forces of the Crown. They were in a position to defend as well as to maintain the Exchanges and plant for which they were responsible, and, in the language of a European ruler, "to exact from all those whom it might concern that degree of respect which they believed to be their due." (Laughter.)

At the conclusion of the dinner, dancing began in the King's Hall and was carried on until midnight, a concert being given concurrently for part of the time in one of the minor halls.

The Committee in charge of the varied entertainment carried through the arrangements in perfect style, and the gathering as a whole proved to be, as formerly, most enjoyable and successful.

COUNCIL NOTES.

A MEETING of the Council was held at the Institution of Electrical Engineers, Victoria Embankment, on April 20th last, Mr. W. Noble presiding.

The Secretary reported that the proposed amendment of the rules to admit clerical assistants as Associates of the Institution had been agreed to, and it was hoped that the necessary Treasury authority would be obtained to give effect to the same so far as facilities for travelling to the meetings were concerned.

Assistant-Secretary.—In view of the growth of the Institution and the increase of work resulting therefrom, the Council appointed Mr. H. W. Senhenn Assistant-Secretary for the current year. Mr. Senhenn is attached to the Superintending Engineer's Office, South-Eastern District, Croydon, and will, until further notice, deal with the subscriptions collected by the local secretaries of the various centres. The members and associates are reminded that subscriptions should be forwarded without delay.

President's Award Competition, 1913–14.—In connection with this competition three engineering and two clerical papers were submitted for adjudication. A prize of three guineas was awarded to Mr. L. B. Jolly, Engineer-in-Chief's Office, for his paper, entitled: "An Introduction to the Theory of Illumination."

Papers Recommended for Printing.—It was decided to print and circulate the following paper:

"Trunk Telephone Communication," by Messrs. A. B. Hart and and W. J. Hilyer, read before the London Centre last session.

Result of the Election of Members of Council and Officers for the Current Year:

Mr. T. F. Purves	Engineer-in-Chief's Office.
„ W. Cruickshank	
„ J. A. Hunt	Exec. Engineers, London.
„ F. McMorrough	„ „ Provinces.
„ W. Dolton	Assist. and 2nd Cl. Engrs., Lond.
„ W. H. Powning	„ „ „ „ Prov.
„ H. Cranage	Chief Inspectors and Sub-Engineers, Provinces (tie).
„ G. Bailey	
„ D. Barradell	Chief Inspectors and Sub-Engineers, London.
„ W. T. Harris	Clerical Officers, London.
„ F. W. Beetlestone	„ „ Provinces.
„ H. E. Adams	„ „ „
„ J. W. Atkinson	Treasurer.
„ T. Smerdon	Secretary.

In the case of the Chief Inspectors and Sub-Engineers, Provincial, a fresh ballot resulted in the election of Mr. H. Cranage.

The Annual Meeting of the Institution was held at 5 p.m. on April 20th, when the President, Mr. W. Slingo, presided.

The Annual Report of the Council was read and adopted. It is hoped to issue the same to the Members and Associates at an early date.

The Council have under consideration the amendment of the rules governing awards, in order that papers such as the one read by Messrs. Hart and Hilyer shall be provided for. According to the existing rules, papers of dual authorship have been excluded when the question of awards has been considered.

T. Smerdon,
Secretary.

LOCAL CENTRE NOTES.

LONDON CENTRE.

On March 9th Mr. A. C. Booth gave a lecture on "Printing Telegraphs," and an interesting feature of the meeting was a very fine exhibition of various printing instruments, some of which were actually working. Sir John Gavey opened the discussion, in which Mr. Newlands, Controller of the Central Telegraph Office, took part.

THE INSTITUTION OF POST-OFFICE ELECTRICAL ENGINEERS
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INSTITUTION MEDALLISTS, SESSION 1912–13.

C. E. HAY,
SENIOR SILVER MEDAL,
"Alternating Current Measurements."

F. ADDEY,
SENIOR BRONZE MEDAL,
"Directive Wireless Telegraphy."

R. MYLES HOOK,
JUNIOR SILVER MEDAL,
"Correct Time."

T. J. MONAGHAN,
JUNIOR BRONZE MEDAL,
"Low Pressure Hot Water Systems."

The 1913–14 Session closed with the Annual General Meeting, which was held on April 20th. At this meeting the President presented the Senior Silver Medal of the Institution to Mr. C. E. Hay for his paper on "Alternating Current Measurements," and the Junior Silver Medal to Mr. R. Myles Hook for his paper on "Correct Time." At the completion of the annual business Mr. D. H. Kennedy read a paper, of which he is a joint author with Mr. J. W. Turner, on "Private Branch Exchanges."

In March two parties of members paid a visit to the Indiarubber and Guttapercha Company's Works, Silvertown. The thanks of the Institution are due to the Works Manager of the Company for the very cordial reception given the members.

Mr. A. W. Martin and Mr. J. M. Shackleton are succeeded as Chairman and the Vice-Chairman of the Centre by Messrs. Purves and Greenham, and the late Committee desire to place upon record their appreciation of the services rendered the Institution by their Chairman and Vice-Chairman.

As the programme for the forthcoming Winter Session is now in course of preparation, the Committee will be glad to receive offers of papers from members.

EASTERN CENTRE.

The second meeting of the Session was held at Cambridge on January 6th, when Mr. J. R. Crocker read a paper on "Warming Buildings by Hot Water." The subject is one which had not previously been introduced at the meetings in this District, and it proved to be of great interest. In drawing a comparison between hot-water systems and heating by open fires some very interesting statistics were given, some of which were compiled from actual records, showing beyond question the superiority of hot-water heating from every point of view. In describing the various systems of heating a number of excellent diagrams were used, and this enabled everyone present to follow the details closely. The "maintenance and care of systems" was dealt with at some length, and the practical value of this part of the paper was fully shown in the interest taken by the members present.

The third meeting was held on February 10th, when a paper entitled "Electric Battery Vehicles for Mail Carrying" was read by Mr. J. F. Lamb. The lecturer commenced with a brief historical survey in which reference was made to the performance of some of the earliest electric vehicles and the weights of their battery equipments compared with those of the latest models. It was stated that recent improvements in batteries and the introduction of the Edison accumulator have led to a great increase in the numbers of electrics in the United States, where there are now close upon 40,000 of these vehicles. People in this country are also beginning to see that there is a large field for electrics, and the formation of a committee of the Municipal Engineers Association specially to deal with this matter should help greatly to popularise the vehicle here. The latest types of lead-traction batteries and the Edison cell were described, and curves illustrating their working under various conditions were shown. The method of calculating the energy consumption of an electric vehicle and the power required to drive it was described in detail, and particulars of a typical vehicle and one or two special makes were given. The various mail-carrying services on which electrics could be employed and the types of vehicle best suited for each service were next discussed, the paper concluding with an examination into the methods of arriving at the costs of running electric as compared with other types of vehicles.

The final meeting of the Session took place on March 24th, when Mr. F. W. Cheshire read a paper on "Main Underground Construction." The paper dealt with the laying of Syke's stoneware multiple-way ducts in connection with the new Eastern Underground Ducts, and various types of jointing couplings and their methods of laying were described in detail. The precautions to be taken as compared with pipe work were next outlined and the cost of the two types of underground compared. The procedure in ordering the cable, delivery and carting, and the force employed and disposition of men during cabling operations were detailed, the lecturer concluding with a description of the jointing and plumbing procedure and full particulars of the testing arrangements. A sample of the cable dealt with and specimen joints were passed round for inspection.

The meetings were all well attended, and their practical usefulness was shown by the interest of the members present and the keenness of the discussions which followed the reading of the papers.

SOUTH-WESTERN CENTRE.

The second meeting of the Session was held on December 8th, when Mr. C. G. Roach gave an interesting and well-illustrated description of the new Land's End Wireless Station.

On January 5th Mr. F. Addey repeated his lecture on "Directive Wireless Telegraphy" before a large audience. The subject is one in which the members of the centre are specially interested, and Mr. Addey's paper was particularly interesting and helpful.

At the fourth meeting in February, Mr. A. Rattue gave a very comprehensive and useful paper on the "Preparation of Local Underground Schemes."

A special meeting was held on February 24th, when the chairman and members of the Council paid a visit to Bristol. Mr. F. Tremain read a paper on "Early Experiments in Loading Telephone Cables."

At the conclusion of the meeting Mr. Noble presented medals to Messrs. Nimmo and Pink. These awards were announced in Vol. vi, part 4, of this JOURNAL.

In the evening the members of the Council were present at the annual whist-drive, concert, and dance of the Bristol Engineering Staff.

The last meeting was held on April 6th, when Mr. C. E. Morgan read a paper on "Common Battery Telephony," which was very fully illustrated by lantern views of various large exchanges.

The Session has been very successful; the average attendance was thirty-eight. W. J. C.

NORTH-WESTERN CENTRE.

A most successful meeting was held in the Lecture Hall of the Preston Scientific Society on March 9th, 1914, when Mr. A. J. Ross contributed a paper on "Stores."

Mr. T. E. P. Stretche (Superintending Engineer) presided.

There was a crowded and representative attendance of engineering and clerical members, and the close attention given during the reading of the paper evidenced the fact that the subject appealed with strong force to both the clerical and technical elements of the gathering.

The subject was dealt with under the three headings of distribution, store-keeping, and stores accounting. Mr. Ross gave a lucid account of the development of store-keeping methods up to the present time, and pleaded for a closer co-operation between the various departments with a view to producing the best possible system of stores accounting.

The paper was enthusiastically received, and provoked an interesting discussion.

Local Organisation, 1914–15.

Chairman: Mr. T. E. P. Stretche.

Vice-Chairmen: Messrs. J. W. Sullivan and J. S. Terras.

Committee: Messrs. W. J. Rolfe, A. W. Field, S. C. Leggett, and D. C. Savory.

Librarian: Mr. H. B. Graham.

Secretary: Mr. D. Barratt.

THE POST OFFICE TELEPHONE AND TELEGRAPH SOCIETY OF LONDON.

On April 27th, the last meeting of the 1913–14 Session was held at the Institution of Electrical Engineers, with Mr. Moir in the chair. The first part of the evening was taken up by the general meeting for the transaction of business and the election of officers for the 1914–15 Session. The balance sheet was presented and accepted, and members were evidently surprised and gratified to find that there was so large a sum as £41 2*s.* 9*d.* in hand.

The following officers were elected for the new Session:

President: The Right Hon. Charles Hobhouse, M.P.

Chairman: Mr. J. Newlands, C.I.E.

Vice-presidents: Sir Alexander King, K.C.B., Sir Chas. A. King, C.B., Mr. E. Crabb, C.B., Mr. A. M. Ogilvie, C.B., Mr. L. T. Horne, Mr. A. B. Walkley, Mr. W. Slingo, Mr. G. Morgan, I.S.O., Mr. G. F. Preston, Mr. A. Moir, and Mr. R. A. Dalzell.

Hon. Secretary: Mr. J. W. Wissenden.

Registrar-Treasurer: Mr. W. K. Cherry.

In electing the Committee it was decided that it would be better for each office concerned to elect its own representatives rather than for the whole committee to be elected at a general meeting, when the votes of one office might overrule the wishes of another office so far as the latter's representatives were concerned. Arrangements were made accordingly.

A vote of thanks to the retiring chairman, Mr. Moir, the popular Superintending Engineer for London, was moved by Mr. Ogilvie, and carried unanimously.

It is proposed to use a large part of the available balance towards the purchase of new books for the Library, etc., and it is hoped that the new arrangements for the borrowing and lending of books will be completed before the opening of the 1914–15 Session in October next. Copies of the papers read before the Society's meetings during the past session are being distributed to all *bona fide* members of the Society as well as to prominent telegraph and telephone officers throughout the country.

J. W. W.

THE O'MEARA CUP COMPETITION.

This competition, which is open to all branches of the Engineering Department, took place during the month of April, and the cup was again won by the Headquarters' Staff team, with a score of 579 points. Thirteen teams had entered this year, but only twelve competed. The scores were as follows:

	Points.		Points.
E.-in-C. "O"	579*	Central Exch. "A"	539
S. District	577*	N.-E. District "B"	523
N. District	574	Central Exch. "B"	515
N.-E. District "A"	566	N. Mid. District "A"	490
S.-W. District	558	Met. Centre External	469
S. Mid. District	548	N. Mid. District "B"	392

Total number of points possible 600.

* After adjudication by the Society of Miniature Rifle Clubs.

The E.-in-C. "O" Team has now won the competition four times out of five, the only team that has beaten them being that of the Northern District. The winning team this year consisted of Messrs. McGowan, Goode, Lawrence, Taylour, Smith, Addey, and Reid.

CHESS CLUB NOTES.

THE Club concluded its playing season on the 31st March last. The League record was a slight improvement on that for the previous season, and a further advance is confidently hoped for when operations re-commence.

Several highly interesting competitions were concluded, the ultimate victors being:

Club Championship	W. A. Wales.
Senior Tournament	E. Turner.
Junior Tournament	D. Regan.
Highest League score	C. W. Care.
Brilliancy Competition	W. A. Wales.

The tenth Annual Dinner of the Club was held on the 21st April, at the Holborn Restaurant, and proved very enjoyable. The Engineer-in-Chief, who presided, was accompanied by Mrs. Slingo, and there was a large number of ladies among those present. The speakers were Mr. Slingo, Mr. Noble, Mr. Moir, Mr. De Lattre, and the Hon. Secretary of the Club; and during the evening the following artistes contributed to a much appreciated musical programme: Miss Burgiss, Miss Goodchild, Mr. Morgan, Mr. Oberst, and Mr. Bolton.

BOOK REVIEWS.

'Wireless Telegraphy: a Handbook for the use of Operators and Students,' by W. H. Marchant. (Whittaker & Co., London. Price 4*s*. 6*d*. net.)

The aim of this work is to furnish students and those engaged in radio-telegraphy with an outline of the various systems and apparatus connected with the subject.

The explanations and descriptions, necessarily somewhat brief, and formulæ, where given, are merely stated, the process by which they are obtained being omitted.

The first portion of the book deals with electric oscillations and the apparatus employed in their production. Then follow descriptions of the various systems in use *e.g.*, Marconi, Telefunken, Poulsen, etc., with a useful chapter on portable stations. The remainder of the book is devoted to measurements, localisation of faults, abbreviations, codes, etc.

The work, on the whole, is excellently got up, the diagrams reflecting great credit on those who prepared them, but a number of misprints occur, viz., on page 84, line 11, "shoot" for "short"; line 19, "charge" for "change"; line 21, "sent" for "send"; and in line 23 the word "is" has been omitted between "circuit" and "removed." On page 174 a serious error occurs in connection with the comparison of capacities by the de Sauty bridge method. It is stated that when a balance has been obtained, $K : K_1 : : R : R_1$. That this is not an accidental slip is confirmed by the subsequent statement: "That is to say, as K is to K_1 so is R to R_1."

In other respects the book will prove to be useful to the class for whom it has, been written.

'The Elements of Electricity,' by Wirt Robinson. Second Edition, 1914. (Published in New York by John Wiley & Sons, Inc., and in London by Messrs. Chapman & Hall, Ltd. Price 10*s*. 6*d*. net.)

There are on the market many text-books on magnetism and electricity, but it is seldom we have encountered one that covers such an extensive field as the above. The writer is a lieutenant-colonel of the United States and professor of chemistry, etc., at West Point Military Academy, and the contents have been prepared originally for the third-year course of the cadets at the well-known New York training school.

The methods adopted throughout the course are very similar to those used by Sylvanus Thompson in his text-book; a brief historical survey is given, and a preliminary excursion is made over the elementary theory before the more intricate and advanced portion of the work is tackled. The book can, therefore, be appreciated by the student approaching the subject for the first time, as well as by those who have already passed through the initiatory stages. Although the terms "intricate" and "advanced" are used above, the subject is not carried to the point of abstruseness—the writer indicates by reference where the student may pursue further specialised treatment—and there is nothing in the work that cannot be grasped by the student possessing but an elementary knowledge of the calculus.

As would be expected, the electric current and its chemical action receives special treatment, and there is a fascinating chapter on the "Theory of Electrolytic Dissociation." In reading through the volume of nearly 600 pages no one, except perhaps a science lecturer at an up-to-date technical school, can help being struck by the enormous advances made in recent years in the application of electricity to industrial processes, and Prof. Robinson is very illuminating on these points.

Well printed, well bound, and illustrated by many drawings which we have not seen elsewhere, the book is one well worth purchasing by the engineer as well as by the student who is anxious to receive a thorough grounding in the subject.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From.	To.	Date.
Lawson, R. J.	Engr., 2nd Cl.	Asst. Engr.	28 : 11 : 13
Pratt, G. F. C.	Chief Inspector	"	14 : 5 : 14
Martin, W.	"	"	14 : 5 : 14
Harper, E.	"	"	14 : 5 : 14
Gaskins, F. W.	"	"	14 : 5 : 14
Pearson, E. A.	"	"	14 : 5 : 14
Bromhead, A.	"	"	14 : 5 : 14
Spargo, A.	"	"	14 : 5 : 14
Hives, F. G.	"	"	14 : 5 : 14

TRANSFERS.

Name.	Rank.	Transferred from.	To.	Date.
Hall, R. S.	3rd Cl. Clerk	S. Midland	London	12 : 2 : 14
Randall, W. J.	"	"	"	12 : 2 : 14
Gravett, E.	"	"	"	12 : 2 : 14
Curling, R.	Chief Inspctr.*	South Eastern	Scot. West	2 : 3 : 14
Neilan, C. E. E.	3rd Cl. Clerk	N. Midland	S. Midland	15 : 3 : 14
Bolt, J. T.	"	S. Midland	N. Midland	15 : 3 : 14
Platt, W.	Asst. Engr.	South Wales	"	18 : 3 : 14
Mallett, E.	"	Scot. West	E. in C.O.	1 : 4 : 14
Jones, L. J.	Prob. Sub.-Engr.	London	"	20 : 4 : 14
Pratt, G. F. C.	Chief Inspctr.*	"	South Wales	23 : 3 : 14
Harper, E.	" *	South Western	Ireland	1 : 4 : 14
Wood, W. K.	Asst. Engr.	North Eastern	N. Western	20 : 4 : 14

* Since promoted to Asst. Engineership.

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All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.

A few copies of Part 1, Vol. 1, of the JOURNAL are required by the Board. Full price will be paid for copies in good condition, or another part can be sent in exchange. The JOURNALS may be sent to the Managing Editor direct, or through the local agents.

Binding covers and copies of the Contents Index for Vol. 6 are now available, and may be obtained from the local agents for 1*s*. and 2*d*. respectively. Subscribers can have their copies bound, with index included, at a cost of 1*s*. 9*d*., by sending the JOURNALS to the local agents. Orders should indicate whether the original binding covers, or the later pattern, are required.

A supply of the first instalment of the Station List of Engineering Officers eligible for membership of the Institution, issued with the preceding number of the JOURNAL, and including all officers down to Assistant Engineers, is in stock, and copies can be obtained on demand, price 3*d*. each.

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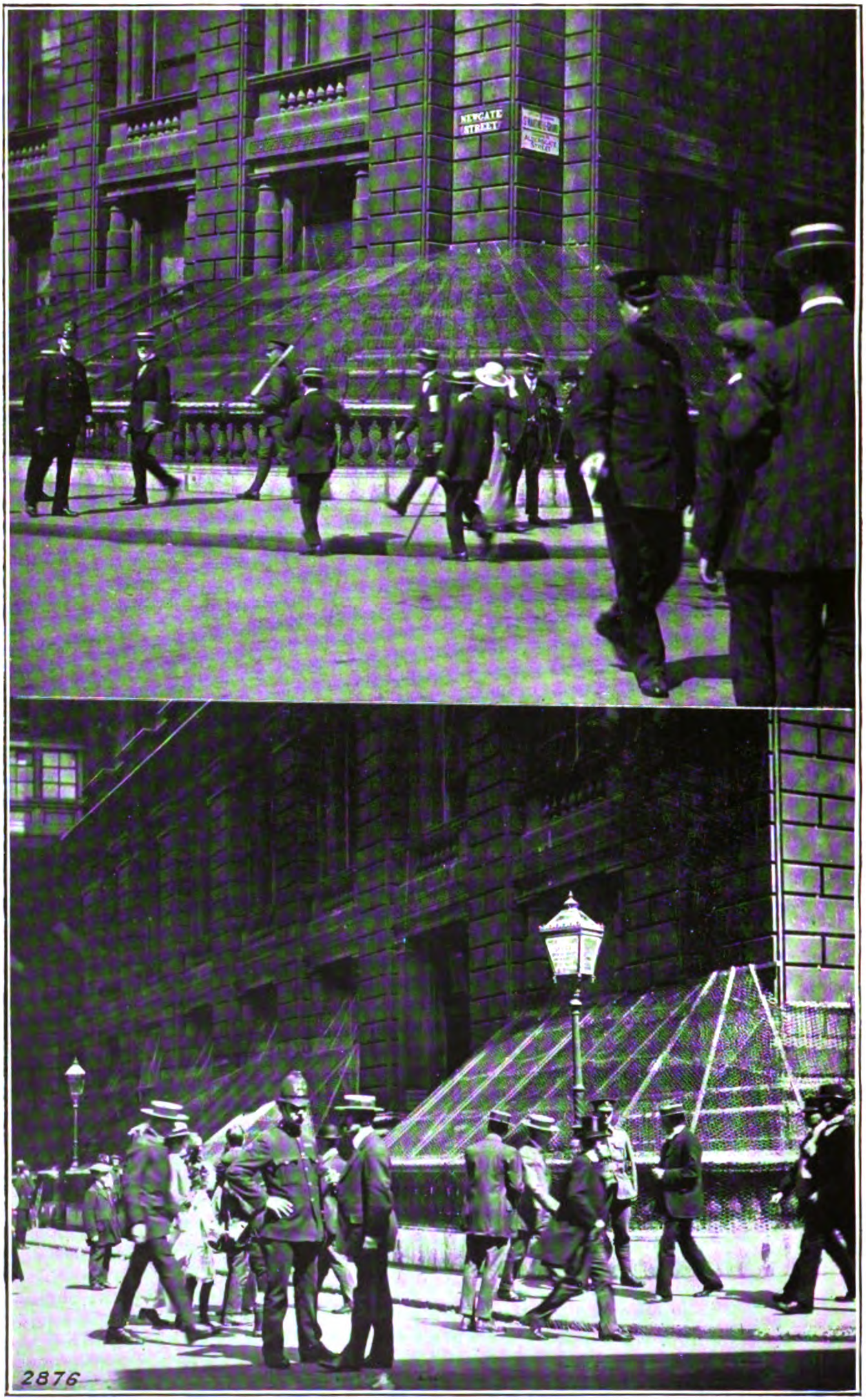


The Central Telegraph Office in War Time.

(1) Newgate Street—St. Martins-le-Grand Corner.

(2) Roman Bath Street—Newgate Street Corner.

THE
Post Office Electrical Engineers' Journal

THE TRAFFIC SIDE OF EXCHANGE DESIGN WORK.

By H. F. E. Deane, A.M.I.E.E.

A GENERAL article on this subject, so far as the writer is aware, has not appeared before. It must be acknowledged that this is somewhat surprising when we remember that the traffic work underlying the provision of switchboard equipment has always been considered an important part of the work of a Traffic Branch. It is true that isolated portions of the subject have been dealt with from time to time, but, to the best of the writer's knowledge, the ground has not been covered before in a general article. It appears desirable, therefore—especially as a good deal of original work has been carried out during the past two years—to take stock of our knowledge of the subject, and to place it before those whom it may interest.

The writer's association with traffic work in London, as opposed to the conditions specially applicable to the rest of the country, compels him to treat the subject, in a great measure, from a London point of view. He feels confident, however, that the greater part of what follows will prove of interest to traffic men generally, especially to those who control large centres of traffic.

One point must be made quite clear at the commencement. With the exception of collecting the materials which compose this article, grouping them in a more or less organised manner, and except for a few personal investigations and suggestions, the writer cannot lay claim to much originality. It is acknowledged that many of the methods to be described must suggest themselves to anyone who has personally dealt with half a dozen proposals for new exchanges or the extension of existing switchboards; but the greater part of the original work is the outcome of investigations made by one or two officers who have studied this subject with particular attention.

The first business of a Traffic Branch in this respect is to collect certain information in order that it may proceed expeditiously with design work, to co-operate fully with that branch of the telephone organisation dealing with development work, and to prepare a sailing chart. To begin with, an accurate record of existing equipment is necessary. This record should preferably be kept on the card system; and, as a considerable amount of information is required, two, or even three, cards may be necessary for each exchange. In London, one card refers to the "A" equipment, another to the "B" equipment, and a third to the desk and miscellaneous equipment. It will not be necessary to enumerate the various items printed on these cards because they recur on the traffic data form to which reference will be made at a later stage. The cards are ruled in such a manner as to show (*a*) what equipment exists, (*b*) extensions and modifications proposed and authorised, (*c*) extensions and modifications completed. The latest information with regard to the equipment is thus available at any time. The co-operation of the Exchange Managers is, of course, necessary in order that the record may be accurate. This implies that the Exchange Managers must keep similar records relating to the exchanges in their districts; that they must be advised by the Traffic Branch of authorised additions to the equipment; and that they must, in turn, advise the Traffic Branch when those additions have been carried out. It is quite astonishing, in practice, how difficult it is for the Traffic Branch to be certain of the exact equipment existing (say) at a large exchange, where, apart from extensions on a larger scale, so many modifications to the apparatus are carried out during the course of time. Indeed, it is found necessary, at intervals, to bring the equipment cards up to date by special reference to the exchange districts.

Apart from the question of operating loads and a system of giving traffic its proper valuation, the three traffic items, obtained directly or indirectly from the peg count records, which form the basis of design work are (*a*) the busy hour originating calling rate, (*b*) the busy hour originating junction calling rate, (*c*) the busy hour incoming junction calling rate—per direct exchange line. In addition, for engineering purposes, it is necessary to know (*d*) the day originating calling rate, (*e*) the day incoming calling rate—per direct exchange line. Lastly it may be convenient, for call valuation purposes, to know (*f*) the percentage of outgoing junction traffic during the busy hour. These particulars are best kept in curve form for each exchange.

It is found in practice that in order to make intelligent studies, the above particulars should be available for five years past. A difficulty, however, at once presents itself in this connection. Unless we can refer to the details of past peg counts, or to a detailed summary of such peg counts giving us the necessary information, we shall experience difficulty in obtaining what we want from the official records as they stand. If we consult the quarterly summaries of operating statistics for exchanges with 300 subscribers and over, we shall have to assume three things :—(*a*) that the ratio of the busy hour to the busy half-hour is approximately 1·9 : 1, (*b*) that the greatest number of operators is on duty at the busy time, (*c*) that the percentage of outgoing junction calls calculated on day figures is applicable to the busy hour. It thus happens that we are forced, when we wish to review the traffic conditions of the past, to employ such information as the day calling rate per direct exchange line, the ratio of day to busy hour traffic, the percentage of outgoing junction calls, etc.

It is very desirable, in order that the past traffic history of an exchange may be as valuable as possible, to specify at the appropriate dates on the traffic data forms any events which may have affected the traffic conditions, such as the conversion of an exchange from magneto to C.B. working, change from "partial" or incomplete multiple to full multiple system, correction of area-transfers, transfer of subscribers to new exchanges, temporary transfer of lines due to load reasons, etc.

We have hitherto assumed that the busy hour is the correct traffic period on which switchboard equipment should be based, and we are probably justified in this assumption when we consider that the period in question bears a simple relation to the time constituting a traffic day, and does not contain a much busier period of such duration as to harass the operators. Opinion differs, however, as to whether the busy hour should be the actual busy hour, or what is called the even busy hour (*e.g.* 10 a.m.—11 a.m.). In the opinion of the writer, the adoption of the even busy hour is somewhat arbitrary. It is true that in practice, it might be inconvenient to ascertain the actual busy hour, and that even if this could be ascertained without difficulty, it would probably be undesirable to arrange the duties of the operating staff accordingly. Speaking generally, the taking of the peg-count record in half-hourly periods satisfies practical requirements very well. If, therefore, it is necessary to take half-hourly peg counts for staffing purposes, it cannot be unreasonable to take any two consecutive half-hours, constituting the "busy hour," for equipment purposes.

As already stated, the full co-operation of the Traffic Branch with that branch which deals with development work is most desirable, and, indeed, essential. It is not sufficient for the Traffic Branch, when it becomes vaguely recognised that an exchange requires extension, to ask for development figures. These figures should be available at the commencement in order that the Traffic Branch may estimate the approximate date of exhaustion of the equipment, and make proposals for the extension of the switchboard in good time. On the other hand, the sailing chart prepared by the Traffic Branch, containing particulars of the remaining life of the various exchanges, is of the greatest service to the Development Branch when questions of creating new exchange areas arise. Later, the details of this sailing chart will be referred to. It will suffice at present to state that the approximate dates of equipment exhaustion it contains are based on the projection of development and traffic data. The chart, in large traffic areas, should be prepared about twice a year.

In conjunction with the development figures, which should preferably be kept in curve form, a curve should be drawn for each exchange showing the percentage of lines on limited rates. This is for the purpose of considering fully questions relating to the provision of registers.

A controversial point of some importance is raised when we consider the traffic data on which exchange equipment should be designed. Some traffic men insist that each case must be considered on its merits; others that it is possible to frame a general rule which will be approximately accurate in all cases. In order that we may consider this important question in detail the daily busy hour calling rates for 1913 have been obtained and examined for four of the principal London exchanges. Two exchanges are located in the city and two in the west end of London. The days neglected are Sundays, Bank holidays and certain weekdays which cannot be considered representative (*e.g.* Saturday between Good Friday and Easter Sunday). Apart from the question of what traffic records are available for use, there are two general methods employed when design studies are made. In the one case average figures are worked to, in the other case an average is taken of all points above the average, and the higher average figure is used. The London peg-count instructions specify that the monthly peg count shall be taken on the busiest day during the last week in each month. If a Bank holiday occurs during this week the nearest busy day before the Bank holiday is chosen. Traffic men will generally agree that this instruction is, in practice, the same as that which specifies that the peg count shall be taken on a representative day.

Let us now examine these busy hour originating calling rates:

Exchange.	Quarterly peg count.		Monthly peg count.		Daily peg count.	
	Average.	Average of points above average.	Average.	Average of points above average.	Average.	Average of points above average.
Central . .	1·41	1·49	1·40	1·48	1·31	1·40
City . . .	1·65	1·70	1·67	1·74	1·53	1·63
Mayfair . .	1·05	1·10	1·05	1·16	·99	1·09
Western . .	·73	·77	·71	·79	·66	·74

Apart from what reasoning we may subsequently employ, it must be generally agreed that if monthly figures are available they are preferable to quarterly figures. If daily figures are available, these are preferable to monthly figures. Daily figures are not available for many exchanges. Monthly figures are only available for London as a whole since August, 1913. In the case of particular exchanges, however, they are available for some time past. Quarterly figures, as we know, are available for many years past for all exchanges with 300 or more direct exchange lines. Except in the case of London, quarterly figures are only available for about one year in the case of exchanges with less than 300 direct exchange lines. It will be noticed, in the case of the four exchanges chosen, that if average figures are worked to there is not a very marked difference between the quarterly and monthly peg-count figures. The daily average figures, however, are considerably lower. It must be remembered, in this connection, that the quarterly and monthly averages are based on busy days.

Until the time arrives when it is thought desirable to take daily records of the busy hour calling rate, the problem is to ascertain, from an examination of such records of this kind as are available, what figure should be used for design purposes, and what similarity exists between this and the available quarterly and monthly peg-count figures at our disposal.

When a proposal is made to build an exchange on average traffic figures, two questions always arise: (*a*) What variation can we allow above the average without affecting the service? (*b*) How often can such variation be allowed without an undue strain upon the operating staff? Let us assume that we put the above questions to an exchange manager. His answer would be somewhat as follows: " I am prepared to work to 5 per cent. above the average whenever it may occur and give the standard service. On particular days I am prepared to work to 10 per cent. above the average with the same result. The operating staff are conscious of these busy days, and they adjust their efforts to the requirements of the situation without affecting the service. I must stipulate, however, that more than two days of this kind do not occur in any one week or you will impose too much of a strain on the staff. In those cases where the load rises above the 10 per cent. margin the service will probably suffer." We will accept this as a working proposition.

Suppose we attempted to work to the average of the daily records. We should, in the case of the four exchanges above mentioned, have to face the following facts:

Percentage of calling rates above the average.	Central.	City.	Mayfair.	Western.
Under 5 per cent. .	26·4	27·5	14·1	12·8
Between 5–10 per cent.	15·1	11·8	18·0	19·0
" 10–15 "	9·4	6·5	11·5	12·8
" 15–20 "	1·7	2·6	4·3	7·9
" 20–25 "	·7	1·0	3·6	5·9
" 25–30 "	—	·3	1·0	1·3
Over 30 per cent. .	·3	—	·3	2·0
Total	53·6	49·7	52·8	61·7

The daily record covered 305 days.

By trial, the writer has come to the following conclusions in the case of each of the above exchanges:

CITY.—The building calling rate should be 5 per cent. above the true average, that is, 1·61. Assuming that the service will not be affected if this calling rate is exceeded by 5 per cent. (*i. e.*, 1·69), we proceed to analyse those cases where this limit is itself exceeded. There are fourteen weeks in the year in which the 5 per cent. margin is exceeded once during the week, and there are three weeks in which it is exceeded twice. In these twenty actual cases, we assume that the operating staff adjust their efforts to the requirements of the situation, and that except where the calling rate exceeds the 10 per cent. margin (*i. e*, 1·76) the service will not suffer. Two weeks remain to be accounted for; one, in which the 5 per cent. margin is exceeded three times (just before Easter) and once when it is exceeded five times (just before Christmas). These are well-recognised exceptional cases. The above case and that of the three other exchanges are summarised in tabular form.

In the case of Central, the two occasions when the 5 per cent. margin was exceeded five times occurred just before Easter and Christmas. In the case of Western, the two occasions when the same margin was exceeded three times occurred during the height of the London season; and the five busy weeks in the case of Mayfair also occurred during the same season. Adopting the "building" calling rates ascertained by trial in order to conform with the requirements of the exchange manager to whom we put the question,

Exchange.	City.	Central.	Western.	Mayfair.
Average calling rate	1·53	1·31	·66	·99
Building " "	1·61 (5 per cent. more)	1·38 (5 per cent. more)	·76 (15 per cent. more)	1·09 (10 per cent. more)
Limit within which service is not affected (5 per cent.)	1·69	1·45	·8	1·14
Number of times the 5 per cent. limit is exceeded in any one week—				
(*a*) Once	14	7	9	3
(*b*) Twice	3	4	4	3
(*c*) Three times	1	1	2	2
(*d*) Four "	—	—	—	2
(*e*) Five "	1	2	—	1

the writer finds from the analysis that in the case of City, Central and Mayfair, there are twenty-eight occasions in the year when the 5 per cent. margin is exceeded. In the case of Western, the corresponding figure is 23.

If the above building calling rates be considered generally satisfactory for design purposes, attention is now drawn to the general similarity between these figures and those representing the average of the points above the average derived from the daily peg counts. The greatest difference is not 3 per cent.

It will at once be pointed out, however, that even if this similarity is consistent and not due to chance, it is useless referring to the "higher average" figure of daily peg counts if the latter are not taken. Assuming, then, that only monthly peg-count figures are available, we find that the actual average of such peg counts is a fairly reliable figure to take in the case of City and Central, whereas the higher average is more applicable in the case of Mayfair and Western. In the former case the monthly peg-count average does not exceed the building calling rate by 4 per cent. In the latter case, the higher average figure from the peg count does not exceed the building calling rate by 7 per cent. Monthly peg counts are, however, only available here and there. Assuming that quarterly peg counts only can be referred to, the figures to be used for design purposes will depend also upon the type of exchange. In the case of City and Central, the average of the quarterly peg-count figures does not exceed the "building" calling rate by 3 per cent. In the case of Western and Mayfair (exchanges with considerable season variations in traffic) it appears more desirable to work to the higher average figure, which does not exceed the "building" calling rate by more than 2 per cent.

Let us summarise what we have said:

(*a*) If quarterly peg counts only are available, the average of such peg counts should be worked to except in the case of exchanges which have season traffic. In such cases the higher average figure should be used.

(*b*) If monthly peg counts are available, the same method appears to be applicable.

(*c*) If daily peg counts are available, the higher average figure appears to be the correct figure to take, unless a detailed study of the case is desirable.

An exchange with season traffic might be defined as one where the 10 per cent. margin above the true average is exceeded in about 20 per cent. of the days in a year.

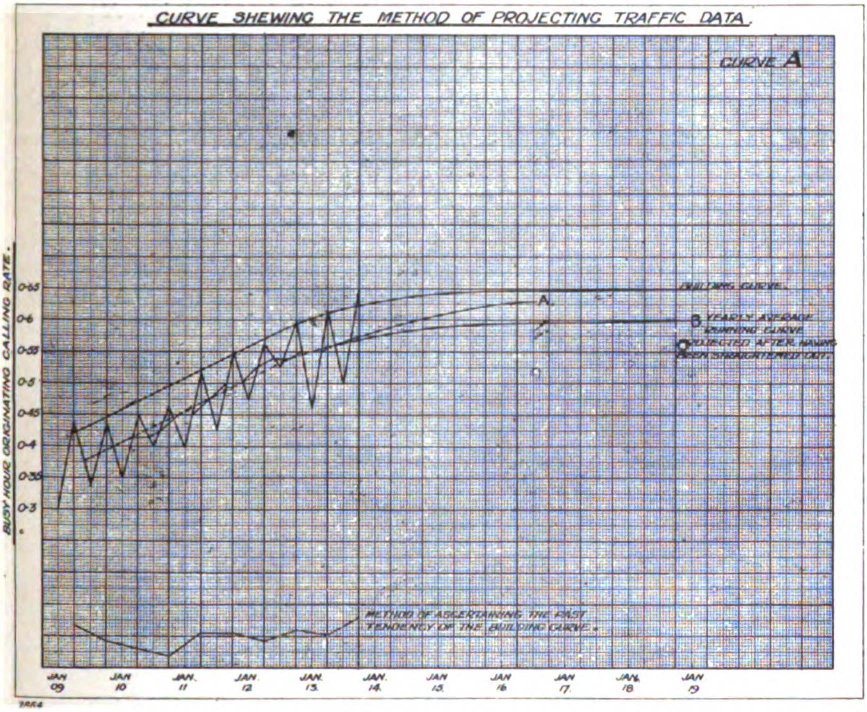
It has already been stated that traffic figures for five years past are necessary for design purposes. This is for the purpose of ascertaining the tendency of past traffic in order to enable us to estimate that in the future. There may be some connection between this period of five years and the period for which the curve is projected for initial equipments and extensions. It is usually agreed, however, that this five-year period is required in practice, and most traffic men agree that any traffic figures prior to the five-year period are not of much service. In exceptional cases, where the calling rate during five years past has been steady, there may be a reason for examining further traffic data.

Let us suppose, for the purpose of illustration, that we have a constant number of subscribers, all on the same service, in a particular district. It is not difficult to conceive that the calling rate of these subscribers will continually increase, chiefly because the telephone system around their particular district is increasing, and partly because the telephone habit gradually replaces other means of communication. The percentage increase in the calling rate will, during the early existence of this hypothetical telephone community, be most probably quite decided. In the course of time, it will become less and less. Nevertheless, an increase, however small, will be maintained, the limiting factor, so far as the calling rate per direct exchange line is concerned, being the capacity of the line for carrying traffic without serious reactive effects upon the service.

If this hypothesis is considered reasonable, a calling-rate curve with a past upward tendency is a more reliable basis to work upon than a steady curve or one with a downward tendency.

In practice, as we know, conditions are not so simple. Even if the total number of lines does not increase materially this may be due to new subscribers taking the place of those who have ceased to subscribe. The effect of this is to level the calling rate, since new subscribers, even if on the same tariff as those that exist, will not make calls initially to the same extent as those about to cease. Under existing rate conditions a considerable development in the number of lines (represented by the difference between the number of new lines and the ceased lines) will generally produce a levelling effect on the calling rate, except in some cases where the calling rate of the new lines is not sufficient to counteract the increasing calling rate of the existing subscribers. Another levelling effect takes place when existing subscribers are forced to take new lines for traffic reasons.

A steady or falling calling rate curve is, therefore, an unsatisfactory thing to deal with. The tendency to remain steady or to fall is due to an artificial state of affairs, and it is difficult to estimate when this will cease to operate. We feel uncertain, under existing conditions, when a steady curve will rise or a downward curve, after attaining its bottom level, will reverse its tendency to fall.



Curve *A* represents the busy hour originating calling rate, during the past five years, of an exchange with season traffic. It is treated in the following manner:

(1) A yearly average running curve is first drawn through the system.

(2) This average curve is then straightened out, due observance being paid to Simpson's rule.

(3) A higher average curve is then plotted, based upon the average

of the points above the average. In order to determine the actual tendency of this curve it is a good plan to consider the base of the curve-form as representing the true average curve, to mark the position of the points above the average on the lower scale and to draw the higher average line. The points of this can then be transcribed above the true average curve.

In this particular case the higher average curve represents, when projected, the building figure.

Let us consider how such a curve as we have plotted should be projected. This projection is partly an art and partly a science based on experience. The "art" consists in having a good eye enabling us to continue the natural tendency of the curve. A person, who knew nothing about telephone work, would probably project the curve in question in the direction *A*. An officer accustomed to exchange design work, and guided by local knowledge, would project it in the direction *B*. When projecting curves of this class he has in mind the calling rates of most exchanges, and therefore knows beforehand the limits between which he can work.

Suppose we examine the quarterly operating statistics for exchanges with 300 direct lines and over. We find no day calling rate below 2 and none above 18. These, then, are the limits under present conditions. For practical purposes we may confine ourselves to the limits between 3 and 12. If, in addition, we possess a general knowledge of the undermentioned table, it will help us materially when estimating. We naturally confine ourselves to certain limits according to the value of the existing calling rate.

Day calling rate.	Percentage of cases.
1–2	·4
2–3	2·3
3–4	14·0
4–5	8·7
5–6	15·6
6–7	14·0
7–8	13·7
8–9	8·4
9–10	5·7
10–11	6·5
11–12	5·3
12–13	·8
13–14	1·9
14–15	1·9
15–16	·4
17–18	·4
	100·

If we are dealing with busy hour figures, we must divide the above calling rates by a figure representing the ratio of the day to the busy hour traffic, the general value of which is between 6 and 7.

The writer has seen some draft designs in which the estimated development during the ensuing five years is not great, and in which it has been considered advisable to lower a busy calling rate considerably during the same period. The result has been that the estimated total originating traffic in five years' time is less than the traffic which exists. We must be careful to avoid this possible error.

A fairly reliable estimate cannot be made for a longer period than five or six years ahead. Whatever has been the tendency of the curve in the past, we are forced to flatten the projected curve out at some point. This is really an acknowledgment that beyond this point we can estimate no further from past tendencies.

In most cases, at present, we are forced to use two curves, namely, the day calling rate and the ratio of the day to busy hour curves in order to determine the busy hour calling rate. Where busy hour figures are available they should always be used. We naturally increase the possibility of error by projecting two curves instead of one.

In those cases where we use the higher average day calling-rate curve, it is a question whether we should use the actual average or the higher average of the ratio curve in conjunction with it. There appears to be no very definite relation between an increase in day calling rate and an increase in ratio. We should expect a higher ratio in such cases, but very frequently we obtain a reverse effect.

When an exchange is converted from magneto to central battery working, a drop in the calling rate may be anticipated with some certainty. It was at one time vaguely assumed that the decreased calling rate, invariably noticed when a change of system took place, was due to over-recording at magneto exchanges, the peg-count records at central battery exchanges being remarkably accurate when compared with the register records. It is now generally acknowledged that the chief reason for this drop in calling rate is the improved facility for supervision of calls which central battery equipment provides. A subscriber on a magneto exchange, when in difficulties with regard to a call made by him, has, generally speaking, only one means of attracting the operator, namely, ringing off, and subsequently calling the exchange a second time. In addition, it should be remembered that the introduction of central battery working in an exchange area improves the disconnection period, and reduces the percentage of ineffective calls. These and other reasons cut down the calling rate.

A number of cases were examined in 1912, and the figures showed that the calling rate after transfer decreased on the average by about 14 per cent. It will generally be recognised that the rate of line development before and after conversion to central battery working is an important factor to bear in mind. Again, the calling rate of an exchange with a small percentage of lost calls will not be affected to the same extent as that of an exchange with a large percentage of lost calls. Taking all these points into consideration, an anticipated drop of 10 per cent. in the calling rate can safely be assumed for general purposes.

In order to make allowance for this decrease in calling rate, all that is necessary is to work to a curve the points of which are 10 per cent. less than those of the projected calling rate curve on which the "A" equipment would have been based if no change of system were anticipated.

A calling rate curve is usually projected twenty years ahead for accommodation purposes, and five years ahead for initial equipment or extension provision. The difficulties in estimating traffic data at such a distant date as twenty years hence have already been noticed. When it is recognised that in line development work a fifteen years' estimate is considered the absolute limit within which a reasonable forecast can be made, it will be apparent that a twenty years' traffic estimate must be a very uncertain quantity. Under present conditions, therefore, we can only regard such an estimate as an intelligent guess. Probably, in the course of time, when the calling rate limits will not be so far apart as they are now under existing tariff conditions, this forecasting difficulty will decrease.

The twenty-year period alluded to is an engineering economic figure for ultimate equipments. It represents an estimate of the useful life of the apparatus, or, to be more correct, that of the oldest portions of it installed. Strictly speaking, the Traffic Branch should estimate the traffic data for more than twenty years ahead when dealing with the ultimate equipment of new exchanges, because a period of time, depending upon circumstances, must elapse before the initial portion of the switchboard can be installed. If, for example, a new building requires to be erected, it is not uncommon for two or three years to elapse between the initial proposal and the opening of the new exchange. In other cases, where merely an addition to an existing building is required or where the desired accommodation exists elsewhere, this waiting period is naturally reduced in length. It would be a useful thing, although an elaborate task, if this period could be determined from past cases of exchanges of varying size, and involving different conditions of transfer. If it is estimated that a new exchange will have a subscribers' multiple of 10,000 lines (the present traffic limit) in twenty years' time or less, it is unnecessary to estimate for a longer period than twenty years.

The length of time initial equipments or equipment extensions should last is another problem in engineering economics. The interests of the Traffic Branch would only require to be consulted if the economic period were so short as to result in very frequent extensions implying interference with the operating, or so long implying the impossibility of a fairly accurate estimate. This economic period, speaking generally, may be taken as five years. Inasmuch as a traffic study has to be made, the proposal has to be approved, the specification has to be got out, the order has to be placed, and the apparatus has to be manufactured, equipped and tested out, it can be easily understood that a traffic estimate six or seven years ahead has to be made, the exact period depending upon circumstances.

It will be obvious that, from a traffic point of view, the longer such a proposal can be delayed with safety, the more accurate will the estimate be, because all the traffic data available at the last moment can be used. It is at this stage that co-operation with the engineering side of the organisation appears so desirable. Suppose, for example, that it takes eighteen months to deal with a 2,000 line extension from the moment the proposal is sanctioned until the equipment is ready for use. To this time has to be added a period of about two months for the preparation and sanction of the proposal. It is apparent, then, that the Traffic Branch must commence its study one year and eight months before the date of exhaustion of the existing equipment. Equipments of varying capacity naturally take different periods to deal with from an engineering standpoint, and, if a switchboard of stock pattern be involved, the economic period above referred to need not be so long as five years, because such a switchboard can be quickly supplied and equipped.

Once an estimate has been made of the future busy hour originating calling rate per direct exchange line, we have to consider what valuation we must give to this calling rate, what loads we must use, and what allowance we must make for the inefficiency of end "A" positions. The writer has no intention of going into details concerning call valuation and load questions. On the one hand, these questions are of such importance in themselves as to warrant separate treatment and, on the other hand, they do not affect the methods involved in dealing with equipment studies. Those who are unacquainted with the principles adopted in London should consult the article by Mr. Maycock, which appeared in previous issues of this JOURNAL.

The general differences between the principles and standards laid down in that article and those adopted by the late National Telephone Company are:

(*a*) The Company's standard of service was also a five seconds average "answer," but this was not necessarily a busy-hour standard. Moveover, the standard implied the answering of definite percentages of calls in specified times. A standard average "clear" was not implied.

(*b*) The unit call was also the full multiple local call, but its time value was conceived generally to be greater than 8·5 seconds.

(*c*) An average value was usually given to the manipulative time values of the various classes of junction calls, depending in a general manner upon the junction facilities. Where the actual time values of junction calls of various classes had been determined, it was difficult to apply them with ease to future conditions.

(*d*) Different loads were used for different types of "A" switchboard equipment. These loads were intended to apply to average traffic conditions.

Some useful figures are contained in Appendix No. 1.

In the writer's opinion the principles now adopted in London represent in many ways a distinct advance over the somewhat rough-and-ready methods adopted by the late Company. It is fair, however, to state that, judging by results (*e.g.* the service rendered to subscribers) the Company's methods were generally successful in practice.

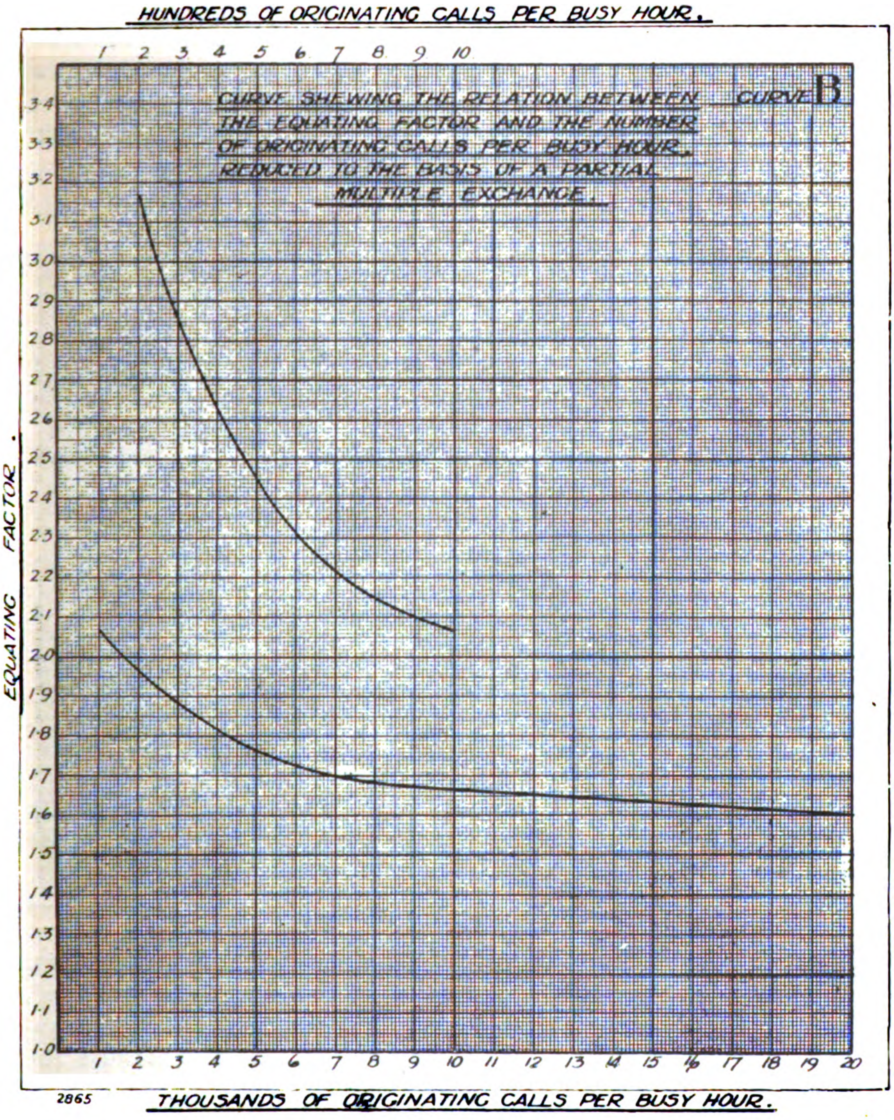
The following suggestions are offered with regard to any future investigations which may be made with the object of perfecting the existing system:

(*a*) It is known that the time value of the unit call varies both at exchanges worked on different systems and at exchanges worked on the same system, but varying in size. In actual practice an increased value is given to the local call at small exchanges, the system of which does not conform with standard methods of operating. This principle should, however, be extended logically to all classes of calls. In London, the fact of giving different values to the unit call at standard exchanges varying in size would make little difference to the average value of the call, not only because the time value of the local value is small, but also because the percentage of junction working is high, apart from the fact that there are several partial multiple exchanges existing. In districts where the percentage of local working is high the point raised might make a considerable difference.

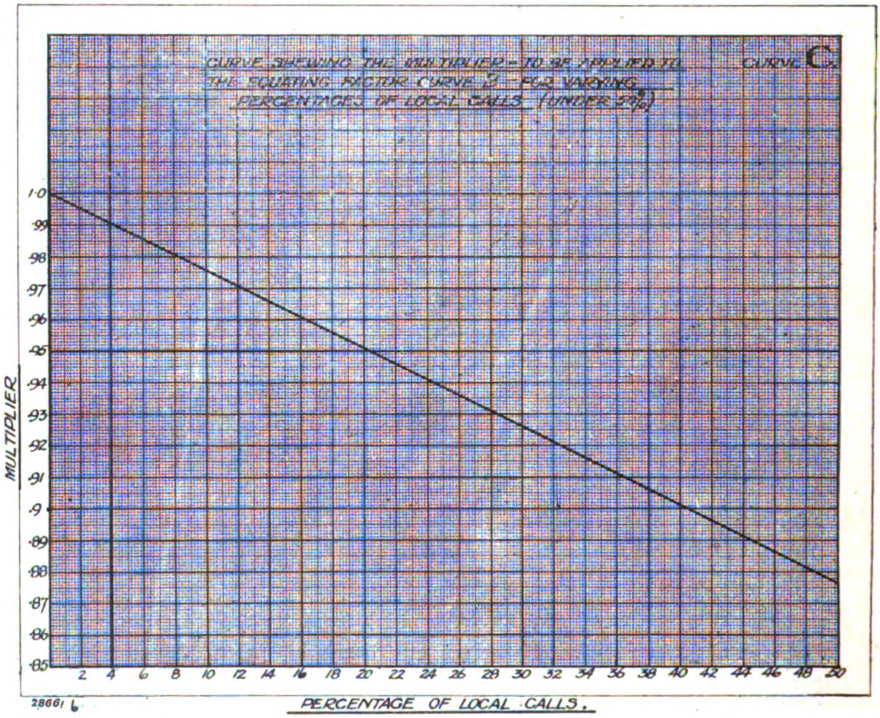
(*b*) The adoption of a definite percentage of occupied time may produce different effects on the service, according to whether a large or small proportion of the calls is of short time value.

(*c*) What occurs during the unoccupied time may affect the operators in different ways at different exchanges.

One of the great advantages of the existing equating factor system is the comparative ease with which the average value of a call may be estimated at future dates. At first, for rough purposes, a curve was drawn showing the general relation between the equating factors determined and the size of the various exchanges expressed in direct exchange lines. This was obviously insufficient for accurate purposes. The next advance in this direction was to draw a curve showing the relation between the equating factors and the originating traffic during the busy hour. This method, however, neglected the following important point.



As the originating junction traffic at an exchange grows the junction facilities are correspondingly increased. We not only add junctions to existing groups, but we increase the amount of direct working. Further, as time progresses, we get a larger proportion of quick junction working. It is not unreasonable to suppose, therefore, that in a large traffic area like London there is a definite relation between the bulk of outgoing junction traffic and the amount and nature of the junction facilities. In other words, we can anticipate with a certain amount of confidence, when the total number of outgoing junction calls at an exchange reaches a particular figure, that there will be a definite proportion of straight order wire working, indirect working, and so forth. The variable factor, therefore, when we attempt to show the relation between the total originating busy hour traffic and the equating factor to be employed, is the percentage of local working. The question is further complicated if we have several partial multiple exchanges, because the proportion of straight order wire calls at such exchanges is considerably above the normal. It was in order to take these points into consideration that curves *B* and *C* were prepared. Curve *B* shows the relation between the total originating busy hour traffic and the equating factors reduced to the basis of a partial multiple exchange, the calculated equating factors at the full multiple exchanges having been revised by valuing local calls as straight order wire calls.



Having predicted the equating factor in this manner for any particular exchange, it is necessary to take into account the proportion of local working which is estimated by examining the "percentage of junction working" curve for that exchange. Curve *C* is used for this purpose.

Example.—A full-multiple exchange is estimated to have 5,000 originationg calls during the busy hour in five years' time and 20 per cent. local working. What is the equating factor applicable at that date?

From curve *B* the equating factor reduced to a partial multiple basis is 1·76.

From curve *C* the correcting factor is ·95.

The estimated equating factor is therefore 1·76 × ·95 = 1·67.

We will now consider the efficiency of "A" operators seated at end positions.

From experiments carried out in London in 1910 the following results were obtained.

Calls answered by operators on their own positions	81·1 per cent.
Calls answered by operators on first position to right or left	17·4 ,,
Calls answered by operators on second position to right or left	1·4 ,,
Calls transferred by supervisors . . .	·1 ,,
	100·

Adopting these figures as a basis, we employ the following reasoning. We must consider average "A" operators as seated at end positions. If we employ senior operators because we know that a fully loaded end position is difficult to operate, we make the distribution on such positions subservient to the ability of the operator, which is a wrong principle. If, in practice, team work does not exist beyond the second position to the right or left of an operator, it follows that if an end position has no positions to its right, the operators occupying the last two positions are affected as regards carrying out team work towards the right. It will also be seen from the table below that to the same extent as these last two operators cannot carry out team work to the right, so they cannot be helped from the right. It might appear at first sight that as the above two conditions balance, the load of operators seated at the end two positions should not be reduced.

Let us assume this to be the standard load, however, and see what kind of answers we get when the following questions are asked:

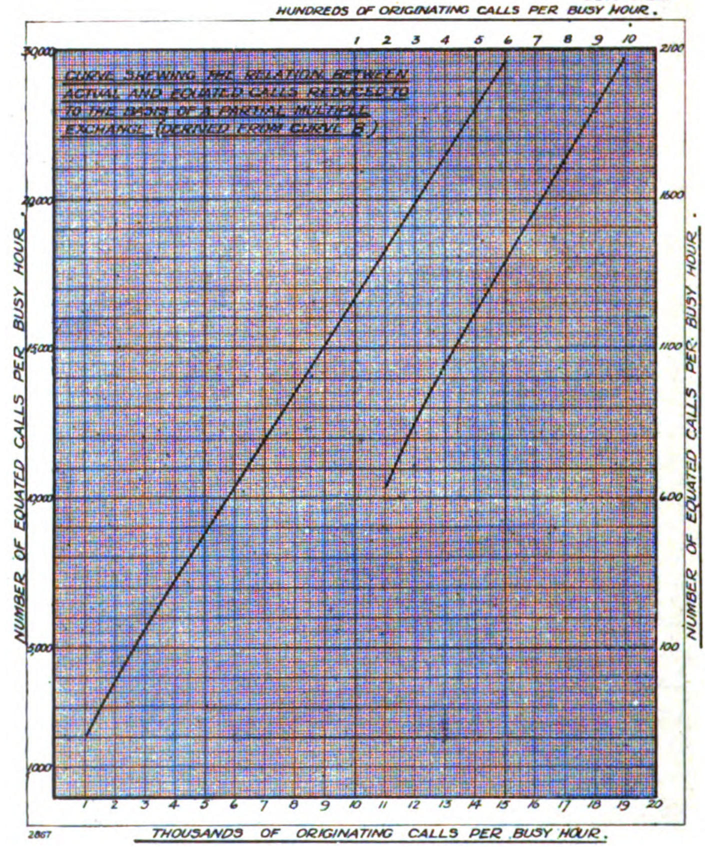
(1) If the last two operators cannot carry out team work (in whole or in part) to their right, why cannot they carry it out to

their left? If we refer to the table, this cannot be done without increasing the standard load on positions 4, 6 and 8.

(2) Why cannot the last two operators answer a higher percentage of calls on their own positions than shown in the table?

If the nature of team work is realised, this is impossible without lowering the standard of service on these positions.

CURVE H



What must happen in practice, therefore, is this: To the same extent as the last two operators cannot be helped from the right, so must their load be decreased. Practically, this resolves itself in reducing the load on the end position by 10 per cent.

It should be noted that if an exchange has only one position, the efficiency of the operator, if the above figures are considered representative, is about 80 per cent. It is usual in London to adopt a general figure of 15 per cent. in order to allow for the inefficiency of end "A" positions.

Position No.	12	10	8	6	4	2	Team work operators 2 and 4 cannot carry out.	
Calls answered by operator 10	8·7	81·1	8·7	·7	—	—	—	—
„ „ 8	·7	8·7	81·1	8·7	·7	—	—	—
„ „ 6	—	·7	8·7	81·1	8·7	·7	—	—
„ „ 4	—	—	·7	8·7	81·1	8·7	·7	—
„ „ 2	—	—	—	·7	8·7	81·1	8·7	·7
Calls distributed by supervisor	·1	·1	·1	·1	·1	·1	—	—
Calls originating on each position	100*	100*	100*	100	99·3	90·6	9·4	·7
Extent (in-calls) to which operators 2 and 4 cannot be helped	—	—	—	—	·7 —	8·7 ·7	—	—

* Obtained by continuing the table towards the left.

We are now in a position to determine the number of "A" positions required at an exchange.

Example.—The estimated busy hour originating calling rate in five years' time at an exchange is 1·5, the estimated equating factor is 1·6, and the estimated line development is 4,000. What initial "A" equipment is necessary assuming two end "A" positions?

$$\text{No. of "A" positions} = \left(\frac{4000 \times 1{\cdot}5 \times 1{\cdot}6}{220}\right) + ({\cdot}15 \times 2) = 44.$$

Once the number of "A" positions required has been ascertained, we have only to divide this number into the total lines which the switchboard is calculated to accommodate in order to determine the number of answering jacks which should be equipped per position. This is a more satisfactory plan than to equip end "A" positions with less answering equipment than is fitted on other positions—even in the case of small exchanges. The load on end positions can always be adjusted by judicious distribution.

The equipment of the actual average number of answering jacks per position calculated to produce the standard load is, in practice, seldom possible in standard C.B.1 switchboards. If we assume for the moment that local jacks should be provided in strips of ten, and if we bear in mind that it is desirable to assemble these jacks in twenties or in multiples of twenty for wiring reasons, it follows that we cannot arrange for an equal number of jacks per position unless it happens that the conditions are satisfied by the fitting of an equal number of jacks per panel, whether in eight- or nine-panel multiple sections.

It usually happens, therefore, that some panels are equipped with more answering jacks than others, with the result that in any particular section of three positions, approximately the correct number of jacks is accommodated. The standard load per position is then arranged for by careful distribution. These principles apply generally to other types of switchboards.

Attention is now drawn to a particular point, the importance of which is commensurate with the size of an exchange. Let us assume that we are dealing with the initial equipment of a large exchange and that sixty "A" positions are calculated to be necessary. The traffic data are such that seventy-seven lines can be dealt with by each "A" operator. We are tempted, for the purpose of symmetry, to order an answering equipment of 240 lines per section. This provision of three unnecessary jacks per position amounts to a waste of 180 jacks altogether. An answering jack and lamp, together with their associated apparatus and cabling cost approximately twenty-five shillings. This "trifling error" therefore costs the telephone administration £225.

In those cases where future traffic particulars are uncertain, it is better, in the writer's opinion, to err on the low side when dealing with answering equipment, inasmuch as it is difficult to recover the apparatus once it has been fitted, and the cabling becomes useless even if the apparatus can conveniently be removed. Additions to the answering equipment can always be made if traffic conditions subsequently permit of this.

It sometimes happens, in consequence of past errors in design, or as the result of some unforeseen circumstance, that the answering equipment cannot all be utilised. The problem, then, is to ascertain how much of it can be used at some future date, and what answering equipment is necessary on the extension. Such a study involves a knowledge of the future calling rate of busy lines and to what extent we can redistribute these busy lines on the answering equipment of the extension.

It will be convenient at this stage to consider the future supply of subscribers' lamp-caps. The method adopted in the past in this connection has been on the following lines: (*a*) Services no longer granted to new subscribers (*e.g.* County of London rate) are neglected; (*b*) services which are stagnant or decreasing as a whole (*e.g.* flat rate) are likewise neglected; (*c*) all other services, except the message and measured rates, are increased in accordance with past tendencies. For example, pay call offices are increased in accordance with their percentage increase during the past five years, or the opals for this class of service may be provided on a ratio basis if this is considered the more accurate course to adopt; (*d*) the remaining services will be the ordinary message or measured rates for which the same lamp-cap is used; (*e*) the proportion of barred and unbarred lamp-caps is estimated to be the same in the future as at present. State of exchange forms or similar statistics are consulted in order to form a fairly reliable estimate.

The coming future use of the plain opal to designate the standard service makes it a difficult matter in many cases to furnish proper estimates, and it often appears desirable to postpone the estimate until the last possible moment. It has even been suggested that the additional lamp-caps necessary should not be included in the specification for an extension, but should be ordered as required. It must be remembered, however, that some protection to the line lamps is necessary during the time the answering equipment on an extension is out of use.

The four chief problems associated with the subscribers' multiple are its necessity, and, if this is proved to be the case, how often it should recur in the panels, what facilities should be given to end operators with regard to it, and the amount of multiple which should be supplied to an exchange of given size.

Under what circumstances the subscribers' multiple can be proved out, and whether it then becomes desirable to employ the ancillary system in some form are complicated questions which can only be briefly touched upon in this article. The tendency in London is to adopt the full multiple system as the standard. Further, very little first-hand information is yet available as regards the efficiency of the ancillary system which is in operation at a few exchanges.

The circumstances which favour the proving out of the subscribers' multiple are :

(*a*) A high calling rate.

(*b*) A high percentage of junction working.

(*c*) A frequent recurrence (in order to satisfy operating conditions) of the multiple in the panels.

The cost saved by dispensing with the multiple has to be balanced against—

(i) Additional "B" equipment (for local junctions) with complete multiple, and additional outgoing junction multiple and order wire keys on "A" positions. Also additional "B" staff and supervision.

(ii) Additional "A" equipment with complete outgoing junction multiple. Also additional "A" staff and supervision rendered necessary on account of the higher valuation of calls and restricted team work.

(iii) Additional operating staff during slack times due to calls having to be answered at the positions on which they originate.

(iv) Effect on the service, even under the best conditions (*e.g.* if order wire selectors are employed) due to local calls having to pass through two hands instead of one.

(v) Additional floor space, lighting, cleaning, etc.

It will be clear, therefore, that each problem has to be treated on its merits. It is difficult to put a cost value on the service (see (iv) above) ; but if it could be proved in a particular case that the saving expected to result from the non-provision of the multiple was only moderate (after the size of the exchange had been taken into account), it would not be difficult to show that the improved service which the full multiple system gives and maintains throughout the life of the exchange, fully justifies the additional expenditure.

It is stated that there is little chance of proving out the multiple if the percentage of junction working is under 70.

The following figures (from the American Telephone and Telegraph Company) may be of interest to those who are unaware of them :

MULTIPLE PROVED OUT.

Calling rate.	Number of direct exchange lines.	Percentage of junction working.
8	Over 2,500	About 80
8	5,700 (approx.)	70
20	Over 1,500	80
20	5,400 (approx.)	70

If the multiple can be proved out, it is probably desirable to introduce some form of ancillary working. It has been estimated that the efficiency of the operating is raised 5 per cent. if we add a multiple to a non-multiple exchange. This increased efficiency is due to improved team work facilities during busy times, and to less operating staff being required during slack times. The introduction of the single ancillary system, under the same circumstances, increases the efficiency of the operating staff, it is estimated, by about 7 per cent. It therefore happens that if the multiple is proved out, the single ancillary system can usually be proved in. The introduction of the double ancillary system, under similar circumstances, is estimated to increase the operating efficiency by about 10 per cent. The increased efficiency in this case will depend to some extent upon the concentrating efficiency of the system adopted.

On the assumption that the subscribers' multiple can be proved in, we have next to consider the question of its frequency in the panels. It is a fact, not always appreciated, that very many details of switchboard construction depend upon the operator's reach. In 1910 some experiments were carried out at a standard exchange with a sloping key shelf. It was ascertained that the lateral reach of an operator was six and a half panels without effort (*i. e.* without the operator rising from the chair or moving the body to the right or left) ; that eight panels could be covered with little exertion ; and that the limit of lateral reach was just short of nine panels. The total panel area covered by an operator without effort is approximately 1,480 square inches.

It will be noticed that the extreme limit of lateral reach (*i. e.* nine panels) corresponds with the usual frequency in London of the multiple on the "A" side. At an exchange such as Gerrard, where the subscribers' multiple recurs once in nine panels (the height above the key shelf of the lower level of the subscribers' multiple is kept constant in modern equipments), it has been calculated that 5,040 subscribers' multiple jacks can be covered without effort. Roughly speaking, therefore, half the local calls in a 10,000-line exchange, such as Gerrard is, can be completed without effort at all. The slightest exertion on the operator's part will extend the range of reach from 5,040 to 6,700 multiple jacks. As the percentage of junction working is 75, it follows that in 8 per cent. of the total originating calls some effort is required to set up the connection. An important point to remember is that in the case of an exchange of this size, it would not help the "A" operators if the subscribers' multiple were repeated once in eight panels instead of in nine. In a word, the effort required to reach particular parts of the multiple is simply transferred elsewhere.

It will be obvious that in smaller exchanges this effort in setting up connections is considerably reduced, and that a nine-panel multiple can be fully justified so far as average conditions in London are concerned. It is only where the percentage of junction working is low that a greater frequency of the multiple may appear necessary; but this is not a condition met with at exchanges of moderate size in London.

On the "B" side, the recurrence of the subscribers' multiple once in every six panels corresponds with an operator's lateral reach without effort. When the nature of a "B" operator's work is taken into consideration, this frequency appears fully justified. Not only is a "B" operator able to establish connections laterally without effort, but interference with the work of adjacent "B" operators is avoided. Speaking generally, if an operator is expected, in practice, to make some effort in reaching particular parts of the subscribers' multiple, then, in the case of "A" operators it is desirable that this effort should be distributed; whereas in the case of "B" operators it is desirable that this effort should be local in order to avoid interference.

At standard exchanges where "A" and "B" positions are in a line, a compromise is effected, due to the high engineering costs which would otherwise have to be incurred, and the subscribers' multiple is made to recur once in every eight panels.

In the case of C.B.10 or C.B.12 switchboards, a subscribers' multiple repeating once in four panels practically corresponds with one which repeats once in six panels in standard equipments; and a multiple which repeats once in six panels nearly corresponds with a standard eight-panel multiple. The six-panel multiple appears, therefore, to be correct for general purposes. In these types of switchboard, the "A" and "B" positions are usually in a line, and the conditions are nearly similar to those in the case of standard switchboards where the " A " and " B " positions are also in a line. The question of dummy positions, however, affects the point at issue as will be seen later. The same general arguments apply to the new C.B.S multiple switchboard.

In the case of 50 and 100 line Magneto switchboards, the standard arrangement is to repeat the multiple once in two panels in the former type and once in four panels in the latter type of board. In order to avoid unnecessary expense the answering equipment is retained as long as possible (by dropping the jacks). As the exchange grows in size, the multiple replaces the answering equipment, and serves both purposes.

In order that an end " A" operator may cover the full multiple, it is necessary to provide a dummy position. The general rule followed is that an operator should not be expected to reach beyond the limits of the adjacent position. In an eight-panel standard section an operator, if seated at an end position without a dummy, is deprived of the multiple in 3⅙ panels. In a nine-panel standard section she is deprived of the multiple in three panels. In practice, therefore, either a position is left spare or a three-panel dummy is provided. It happens in London that the first " A" position usually accommodates the electrophone equipment. The multiple over this dummy position provides practically full facilities to the first " A " operator. As regards the last " A" position, a good deal depends upon circumstances. If a testing position is equipped, the multiple over this provides full facilities to the last " A " operator. Whether the testing position should itself be provided with full multiple facilities depends upon the amount of work carried out by the testing operator. If a plugging up position is provided, the multiple over this provides full facilities to the testing operator. Whether full multiple facilities should be provided on a three-panel dummy section, or on an additional regular section, is an engineering question dependent upon what method is employed of storing the cables. In order to provide similar facilities on the " B " switchboard, a position is likewise left spare or a dummy provided. In this case, however, the requirements of the Traffic Branch are satisfied by the provision of two-panel dummy, whether in the case of eight- or nine-panel sections,

If the multiple recurs once in two or four panels, no dummy position is necessary. It is true that operators seated at end positions on such switchboards have not the same facilities as other operators ; but if the problem is considered from the point of view of the operator's reach, and the general rule that reaching beyond the limit of the adjacent position is to be avoided, the facility provided is sufficient for practical purposes.

It has already been stated that in the case of C.B.10, C.B.12 and similar switchboards, a six-panel multiple is all that is generally necessary to satisfy operating conditions. If this frequency is adopted, dummy positions become inevitable. In the case of small switchboards it will be evident that the provision of such positions might be more expensive than the provision of a four-panel multiple. We have, therefore, to consider how many sections will ultimately be required. If we bear in mind that an unequipped dummy section costs £40, and that a single multiple jack, including the cabling, costs 1*s*. at a No. 10 exchange and 1*s*. 6*d*. at a No. 12 exchange, we can make our own calculation in any particular case.

If an exchange of this type is likely to have a busy order wire position it may be advisable to equip a four-panel multiple.

To what extent the capacity of the multiple should exceed that of the answering equipment was ascertained some time ago. A record was taken at each London exchange just prior to the publication of the directory. This record showed the maximum number of multiple numbers which could not be utilised for legitimate traffic reasons. Speaking generally, a 5 per cent. margin was considered sufficient for practical purposes.

It will be recognised that whether this margin answers the requirements of each particular case is never felt until the multiple capacity is nearing exhaustion. The reservation of auxiliary numbers for subscribers who are likely to be busy in the future (a procedure adopted in every well-ordered exchange) is another point which cannot be neglected. Whether special allowance should be made for this is doubtful. In the writer's opinion it is better to treat each case on its merits. In some cases the usual 5 per cent. margin provides sufficient allowance for spares unavailable in consequence of both directory and number reservation reasons. Again, the proportion of numbers reserved varies considerably in different exchanges, and the telephone administration has a right to inquire whether it can, in all cases, afford to have so much apparatus lying idle, after duly considering the probable future effects which changes of number produce.

In the case of small exchanges the 5 per cent. multiple margin necessitates designing to the nearest strip of twenty multiple jacks. In large exchanges we design to the nearest block of a hundred multiple jacks. For example, a 600-line exchange requires 640 multiple jacks and a 5,000-line exchange requires 5,300 multiple jacks. In the latter case 5,260 multiple jacks would, strictly speaking, be sufficient, but the complete hundred block is wired for cabling reasons and for the sake of symmetry. It should be noted that although this unnecessary equipment represents capital lying idle for the time being, it does not necessarily represent wasted plant.

No 5 per cent. multiple margin is necessary if distribution facilities are not provided. An I.D.F. is probably unnecessary unless there are more than three positions.

It will be clear that subscribers' number plates should be supplied to correspond with the total multiple jacks, and not with the total answering jacks.

Opportunity should be taken to straighten out multiple numbering which is not consecutive when extension becomes necessary.

The provision of registers must primarily depend upon the number of calls on which it is necessary to make out a junction fee ticket. If this be great it is better to make out a ticket for each call than to register on each connection, and, in addition, make out a junction fee ticket in the majority of cases. It is only in the case of the smaller exchanges that the provision of registers cannot, as a rule, be proved in. The utility of registers for traffic record purposes will be appreciated. In those cases where registers are employed there are at present three methods of considering what number actually is required: (1) We may consider the limited services only and supply a register for each line of this class. Past records of limited services, as already stated, help us to anticipate the number of registers required in the future. This method becomes obsolete directly the unlimited service is dispensed with. (2) We may provide a register for each working line. This implies that the registers must be connected to new lines as required. (3) A register may be provided for each multiple line, and, in consequence, will be permanently wired to each line. The traffic advantage in this case is that the number of the register and that of the subscriber's line coincide. This is not of sufficient importance, however, alone to justify the additional expense. Such a provision may be justified from an engineering standpoint when the material and labour required to carry out the necessary "jumpering" is taken into account. It is probable that in the case of the larger exchanges the cost of providing one register per multiple line is fully justified.

The various headings of a sailing chart suggested by the writer are shown in Appendix 2. The Development Branch should be in a position to give item 13. On account of the large amount of correction of area transfers (the extent of which is limited by the capacity of the Engineering and Traffic Branches to deal with the work at stated times) it is not always possible to anticipate with exactness the development during the ensuing two and a half years, and considerable judgment has to be exercised. Item 17 is sometimes abnormally low, due to recent transfer work.

Appendix 3 represents the combined traffic data and design form used in London. It is not so elaborate as that to which traffic men in the Provinces are accustomed for two reasons: (1) The complications associated with trunk working are absent; (2) Queries can be settled on the spot.

APPENDIX No. 1.

	London Telephone Service.	N.T.Co.
1. Time value of the unit call (full multiple C.B.)	8·5 sec.	—
2. Relative value of various calls		
Local call (full multiple C.B.)	1·0	1·0
„ (small exchanges)	1·47	—
Junction call. Straight order wire	1·52	1·4
„ Split order wire	1·69	1·5
„ Ringing	2·73	2·0
„ Order wire and lending	3·30	2·4
„ Ringing and lending	3·70	3·0
„ Tandem	1·05	—
Money-box call	2·80	—
Value for ticket work	5·0 sec.	—
3. "A" operators' loads		
Type of exchange:		
C.B. 1	220	200
„ 10		
„ 12		
C.B.S. (new type)		
C.B. 9		190
C.B.S (old type)		
Magneto (self-restoring indicators)		
Magneto (hand-restoring indicators)		180

APPENDIX No. 2.

SAILING CHART.

1. Exchange	North.	South.
2. Number of "A" positions equipped	10	etc.
3. „ end "A" positions	2	
4. „ Traffic "A" positions	9·7	
5. Existing equating factor	2·067	
6. Estimated percentage of local work 2½ years hence	20	
7. Capacity of "A" positions expressed in equated calls	2,134	
8. Capacity of "A" positions expressed in actual calls	1,091	
9. Existing number of direct exchange lines	780	
10. Number of direct exchange lines allotted but not connected	20	
11. Total direct exchange lines existing and allotted	800	
12. Existing originating busy hour calling rate	1·25	
13. Estimated direct exchange lines 2½ years hence	900	
14. Estimated busy hour originating calling rate 2½ years hence	1·26	
15. Traffic capacity of "A" positions expressed in direct exchange lines.	868	
16. Subscribers' multiple. Jacks fitted.	960	
17. „ „ Jacks actually available	914	
18. Number of answering jacks fitted	920	
19. Traffic capacity if multiple or answering equipment is the controlling factor	—	
20. Total available spares	68	etc.
21. Date of exhaustion	1 yr. 8m.	over 2 years.
22. Remarks	Extension study in hand.	

APPENDIX NO. 3.—*Schedule A*.

............EXCHANGE. TRAFFIC PARTICULARS.

	Existing.	Estimate of conditions at.	
1. Number of direct exchange lines . . .			
2. Originating calls per line per day . . .			
3. Ratio of day to busy hour (originating traffic) .			
4. Originating calls per line per busy hour . .			
5. Total originating calls per busy hour . .			
6. Equating factor			
7. Equated calls per busy hour			
8. Number of end "A" positions			
9. "A" positions required: $\frac{\text{Item 7}}{220} + (\cdot 15 \times \text{Item 8})$			
10. Subscribers' multiple (Item 1 × 105 per cent.)			
11. Percentage of outgoing junction calls . .			
12. Incoming calls per line per busy hour . .			
13. Junctions:			
(*a*) Outgoing ("A" positions only) . .			
(*b*) Outgoing ("B" positions only) . .			
(*c*) Incoming			
14. Service lines			
15. Junction jacks required:			
(*a*) (Item 13*a* + Item 14) × $\frac{20}{17}$ . . .			
(*b*) (Item 13*b* + Item 14) × $\frac{20}{17}$ . . .			
16. Order wires (including those required for the testing operator and instruction circuits) .			
17. Inquiries, etc., dealt with at information desk per busy hour.			
18. Average holding time. From the commencement of call until—			
(*a*) Called subscriber answered . . .			
(*b*) End of conversation			
(*c*) Disconnection by operator . . .			

Schedule B.

............EXCHANGE. PARTICULARS OF EQUIPMENT.

Particulars.	Initial or existing.	Ultimate or extension.
1. Type of exchange		
2. Number of "A" positions for:		
(*a*) Answering subscribers' calling signals .		
(*b*) Testing operator		
(*c*) Plugging up		
(*d*) Electrophone		
(*e*) Information purposes		
(*f*) Jack-ended junctions		
(*g*) Total		
3. Number of dummy end positions ("A" board).		
4. Capacity of subscribers' multiple:		
(*a*) Over "A" switchboard		
(*b*) Over "B" switchboard		
5. Numbering of subscribers' multiple . . .		

Schedule B—continued.

Particulars.	Initial or existing.		Ultimate or extension.	
6. Number of panels per subscribers' multiple:				
(*a*) Over "A" switchboard				
(*b*) Over "B" switchboard				
7. Outgoing junction multiple (including service lines):				
(*a*) Number of panels per multiple . .				
(*b*) Capacity over "A" switchboard . .				
(*c*) Number of strips of jacks with designation strips.				
(*d*) Number of strips of jacks without designation strips.				
(*e*) Capacity over "B" switchboard (with designation strips).				
	Sections.	Jacks per section.	Sections.	Jacks per section.
8. Number of answering jacks:				
9. Number of registers				
10. Number of cord circuits per "A" position .				
11. Number of order wire keys per "A" position .				
12. Number of keys associated with order wire lamp.				
13. Number of "B" positions				
14. Number of dummy end positions ("B" board)				
15. Number of cord circuits per "B" position .				
16. Composition of incoming junction equipment:				
(*a*) C.B. order wire				
(*b*) Magneto order wire				
(*c*) Trunk order wire				
(*d*) Suburban trunk				
(*e*) C.B. signal				
(*f*) Magneto signal				
(*g*) Trunk signal.				
(*h*) Jack-ended				
• (*i*) Monitor order wire				
(*j*) Local transfer				
(*k*) Miscellaneous				
(*l*) Total				
17. Number of positions for:				
(*a*) Exchange Manager				
(*b*) Chief Supervisor				
(*c*) Information purposes				
(*d*) Assistant Supervisors				
(*e*) Other purposes				

[*In our next issue Mr. Deane will discuss the various factors that have to be considered in the determination of future junction equipments.* —Eds. P.O.E.E. Journal.]

SPLIT ORDER WIRE "B" POSITIONS: IMPROVEMENT IN WORKING BY THE EMPLOYMENT OF AUTOMATIC SWITCHES.

By R. L. BELL, B.Sc.

As readers of the JOURNAL are aware the amount of traffic which can be handled by an operator on a split order wire "B" position is generally limited by the quality of speech transmission on the order wires rather than by the ability of the "B" operator to deal with the load. This limitation is, of course, due to the reduced efficiency in transmission resulting from the connection in parallel of several order wires. It naturally follows that the removal of the transmission difficulty from these positions will, in general, allow of a larger number of order wires per "B" position, with a consequent economy in the cost of operating and exchange equipment.

A further disadvantage of split order wire working is to be found in the difficulty experienced by exchange managers in allocating small order wire junction groups to "B" positions so as to ensure a reasonable amount of traffic at each position, without excessive reduction in the quality of speech on the order wires. The distribution of the various small order wire junction groups on "B" positions has to be made carefully, and in the first case probably experimentally, since it necessitates reference to the transmission characteristics of each order wire, and also to the amount of traffic on the group of junctions it controls. As the latter factor is a constantly changing quantity re-distribution is required from time to time involving considerations of transmission and traffic on each occasion. It is found in practice that to obtain a reasonable load for the operator the quality of the speech on the order wires is generally affected sufficiently to cause occasional connections to wrong junctions and subscribers' numbers, and this in itself constitutes a serious defect in the present method of split order wire working.

These disadvantages have long been realised by telephone engineers, and investigations covering a considerable period have been made with a view to the development of a more efficient induction coil than those at present in general use, but although the improvement achieved in this direction is substantial, its application to split order wire "B" positions is a palliative rather than a remedy.

No particular transmission difficulty is experienced in straight order wire working, and it is obvious that if the transmission conditions of the latter can be approximated to on split order wire positions, *i.e.*, if only one order wire at a time is connected to the "B" operator's telephone, the disadvantages which have been stated will vanish, provided that no time is lost in switching the "B" operator's telephone from one order wire to another. The advent of reliable automatic switching suggested a means of effecting this result, and a scheme has been devised in which the employment of an automatic switch at a split order wire "B" position ensures that only one order wire at a time is connected to the "B" operator's telephone. This renders split order wire working practically equivalent to straight order wire working so far as transmission is concerned, but it has the additional advantage that the adverse effect on transmission of a number of "A" operators in parallel on one order wire will not be as great in the split order wire case as in the straight order wire case on account of the greater amount of traffic carried by the latter. Some benefit to the service also accrues from the fact that "breaking in" by "A" operators on one order wire on the conversation of operators on another is impossible under this system.

In this scheme a split order wire "B" position has associated with it one automatic switch, consisting of a number of sets of contacts mounted in a bank, and a set of arms which can be made to rotate over the bank contacts. These arms can be brought to rest in electrical connection with any one set of bank contacts at a time. Each of the order wires is connected to one set of bank contacts, and the "B" operator's telephone is connected to the set of arms. The "B" position is provided with the usual junction equipment, and in addition, a strip of lamps, one for each order wire, is placed in the keyboard or in the panel. Whenever one or more "A" operators are waiting on an order wire which is not for the time being connected to the "B" operator's telephone, the lamp corresponding to this order wire glows. The fact that the "B" operator may be connected to one order wire whilst "A" operators are waiting on other order wires immediately suggests the necessity of giving the "B" operator some means of causing the automatic switch to disconnect her telephone from one order wire and to connect it to the next one which has "A" operators waiting on it; otherwise, one order wire could monopolise the use of the "B" position. For this purpose a non-locking key, known as the transfer key, is provided, and is mounted in the centre of the keyboard, so that the "B" operator can manipulate it with either hand. When this key is momentarily actuated the "B" operator is disconnected from one order wire and almost instantaneously connected to the next order wire, on which her attention is required.

If the "B" operator is disengaged, and an "A" operator at a distant exchange depresses the appropriate order wire key, the automatic switch connects the order wire to the "B" operator's telephone, and the call is dealt with in the usual way. During the fractional part of a second taken by the automatic switch to connect the "A" and "B" operators, a "busy" tone is sent out to the former, preventing the demand being passed too quickly, and thus obviating repetition or connection to a wrong number in consequence of the "B" operator hearing only part of the demand.

If one or more "A" operators on one order wire are for the time being connected to the "B" operator whilst "A" operators are waiting on other order wires, the lamps on the "B" position corresponding to the waiting order wires glow as already described, and the "busy" tone is sent out on all of them. Under these conditions the "B" operator deals with one call on the order wire to which she is connected, and then momentarily throws the transfer key, breaking the connection from this order wire and connecting her telephone to the next order wire on which an "A" operator is waiting. The "busy" tone is immediately removed from the order wire just connected, advising the "A" operator of access to the "B" operator, and the lamp on the "B" position corresponding to this order wire is extinguished. At the same instant, if there is an "A" operator waiting on the order wire just disconnected, the "busy" tone is sent out on it, and the corresponding lamp on the "B" position glows. The "B" operator can now deal with a call on the order wire to which she has become connected.

As long as any of the order wire lamps on the "B" position are glowing, the "B" operator is aware that her attention is required on other order wires besides the one to which she is connected, and in these circumstances she deals with one call on each in turn, momentarily throwing the transfer key when she desires to switch over from one order wire to another.

RESULTS OF A PRACTICAL TRIAL.

One of the incoming keyless ringing junctions at the Central Exchange, London, has been equipped by Messrs. Siemens Bros. and Co. with an automatic switch and associated apparatus designed to give the facilities already described.

Five order wires controlling incoming junction groups from Bromley, Enfield, Finchley, North and Purley have been joined up to this switch. The standard cable equivalents of these order wires are 15, 11, 9·5, 3 and 13·5 miles respectively. The effect was tried of connecting them in parallel and working under ordinary split order wire conditions, but the number of repetitions was so high—approximately 75 per cent. of the total number of "A" operators' demands and the "B" operators' replies—as to render this method of working quite impracticable. This was with an experimental induction coil at the "B" position having a higher transmission efficiency than any of the operator's induction coils at present in general use.

With these same order wires working on the automatic apparatus no transmission difficulty has been experienced. Under the latter conditions the operator on this "B" position has dealt with 360 calls in the busy hour without difficulty and with no complaints from the distant exchanges. The average number of busy hour calls dealt with heretofore on split order wire "B" positions equipped with keyless ringing junctions and five order wires is 290. This figure is not applicable as a standard for determining the load which can be dealt with on individual "B" positions, as obviously the loads on different "B" positions must vary widely. As a basis of comparison with the load of 360 calls obtained by the employment of an automatic switch the figure of 290 can, however, be legitimately used; the relation these two figures bear to each other gives a fairly accurate indication of the reduction in the number of split order wire "B" positions and in the cost of operating them which would result from a general application of the automatic system.

Quite apart, however, from the reduction in equipment and operating costs, other benefits are obtained by the employment of automatic switches on split order wire "B" positions. The reduced possibility of "breaking in" by "A" operators minimises the number of connections to wrong junctions. The improved transmission conditions also reduce the number of connections to wrong junctions and to wrong subscribers. It is perhaps reasonable to claim that, on the grounds of the improvement to the service alone, the general use of automatic switches on split order wire "B" positions is justified.

NIGHT CALLING AND EMERGENCY ARRANGEMENTS.

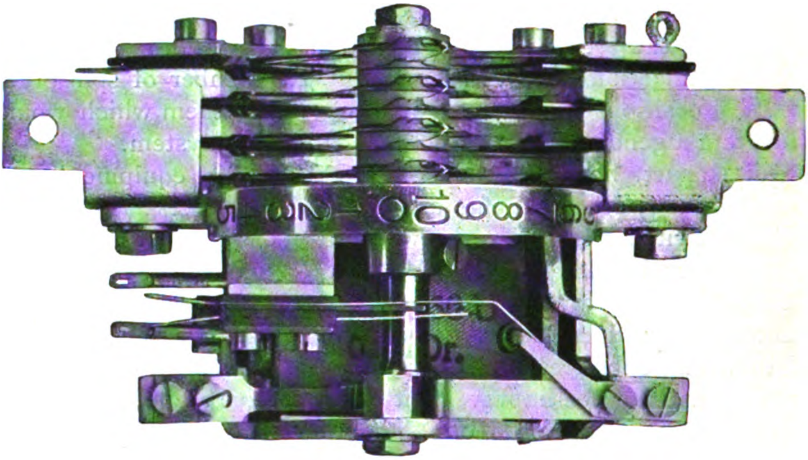
When the traffic is slight and the "B" position is unoccupied, a special night-bell key is thrown. In these circumstances the depression of an order wire key at one of the distant exchanges lights a pilot lamp at the "B" position. The standard method of calling, however—*i.e.* by ringing on the order wire—does not give rise to any trouble, and the calling signal is given in either case. The circuit arrangement at the "B" position is such that for both day and night working no modification is necessary at distant exchanges where standard C.B. conditions obtain.

If the automatic apparatus in connection with one particular order wire fails it can be cut out by throwing an emergency key individual to that order wire. The effect of this is to connect the order wire direct to the "B" operator's telephone, without interfering with the automatic operation of the remaining order wires.

If a fault develop on an order wire beyond the "B" position the order wire can be replaced by one of the junctions in the group it controls by simply inserting the two plugs of a double-ended cord into two jacks mounted in the panel at the "B" position.

CIRCUIT OPERATION.

The automatic switch used is of the type employed by Messrs. Siemens Bros. & Co., for line switches (or preselectors) in automatic exchanges. It is shown in front view in **1**, and in side view in **2**. It consists essentially of a bank of contacts, three sets of arms, which can be brought to rest in electrical connection with any one set of bank contacts, and a driving magnet, which steps the arms over the bank contacts when interrupted current is passed through it. The bank contacts, seen clearly on the left of **2**, occupy a little less than one-third of the circumference of a circle. The arms are arranged radially at 120°, so that immediately one set of arms leaves the last bank contacts the next set of arms is stepped on to the first. In this manner electrical connection is made with each set of bank contacts three times in one revolution. The driving magnet seen on the right of **1** carries on an extension of its armature a thrust-spring, shown on the extreme right of **1** and **2**. When the driving magnet is energised this thrust-spring engages a tooth of a ratchet-wheel (partially obscured by a nut in **1**) fixed to the spindle which carries the arms, and these latter are stepped on to the next bank contacts. The numbered ring enables the maintenance man to tell at a glance which bank contact the arms are connected to.

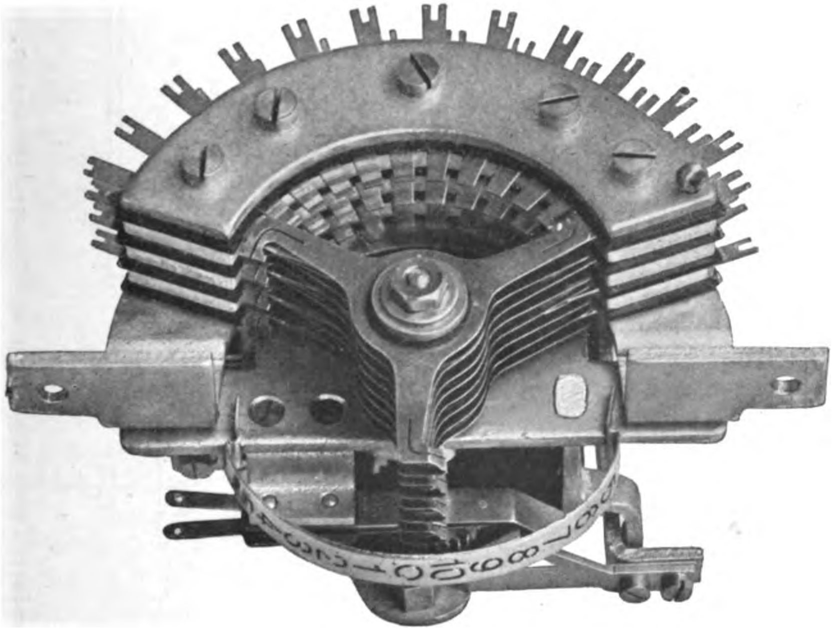


1.—AUTOMATIC SWITCH—FRONT VIEW.

3 shows the circuit arrangement of the automatic switch having five order wires from Exchanges V, W, X, Y, and *Z* connected to the bank contacts; the full connections of the V order wire are given.

Consider first the case of a call on the V order wire when none of the other order wires is in use, and assume that the call just preceding was from exchange W; the switch arms are therefore resting on the bank contacts of the W order wire.

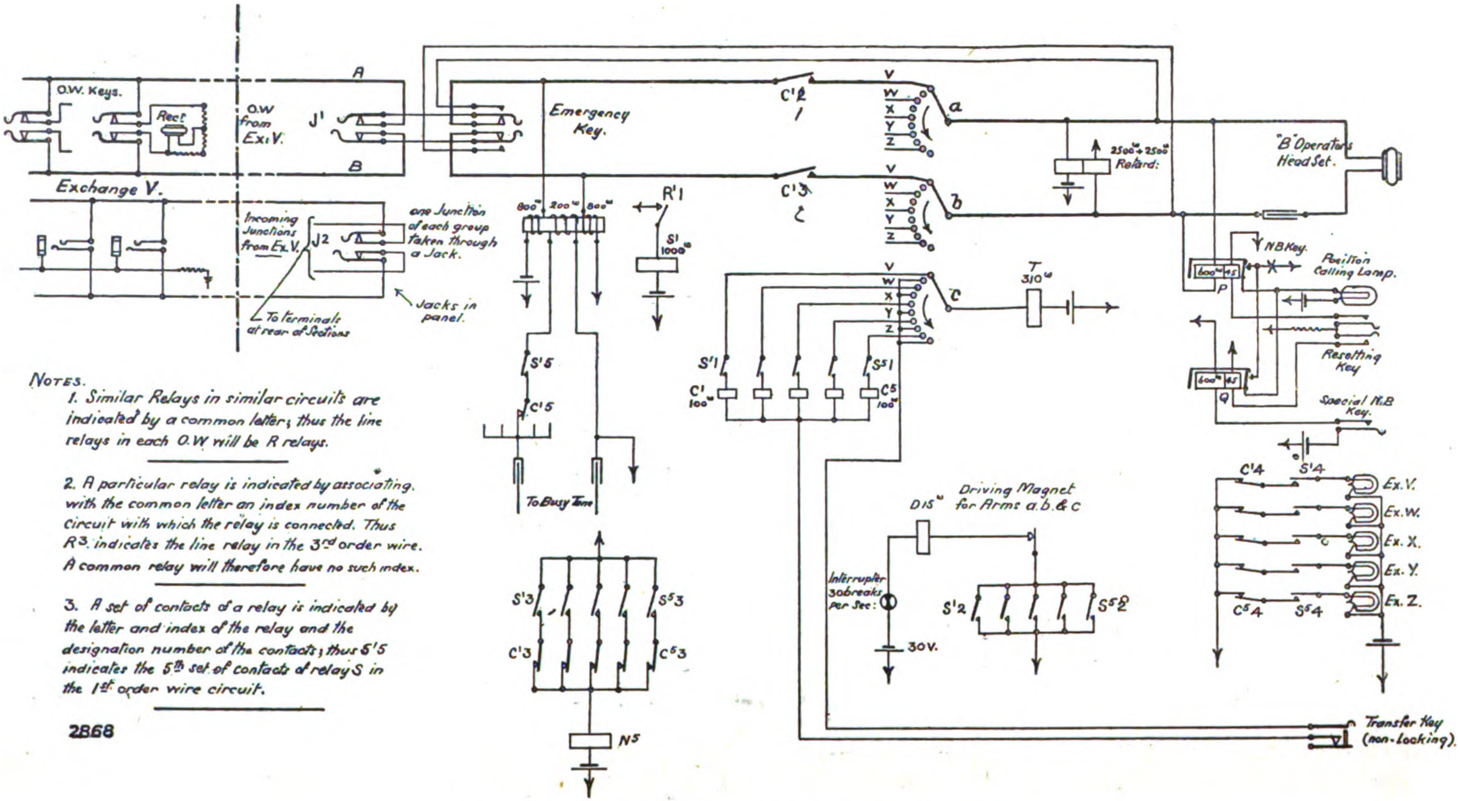
The depression of an order wire key by an "A" operator at Exchange V connects her telephone set across the order wire and completes a circuit from earth through $R^1$800, *B* line, "A" operator's receiver and induction coil, *A* line, $R^1$800 to battery.



2.—AUTOMATIC SWITCH—SIDE VIEW.

Relay R^1 operates and contacts $R^1$1 complete the circuit of S^1.

Relay S^1 operates; contacts $S^1$1 making, prepare the circuit of C^1; $S^1$2 making, complete a circuit from earth through $S^1$2, *T*1, driving magnet *D*, interrupter to 30 *v.* battery; $S^1$3 making, complete a circuit from earth through $S^1$3, $C^1$3, *NS* to battery; *S* 4 making, completes a circuit from earth through $C^1$4, $S^1$4, lamp to battery, thus causing lamp of Exchange V to glow. $S^1$5 making, completes a circuit from busy tone through condenser, $R^1$200, $S^1$5, $C^1$5 condenser to busy tone, which is induced into the two 800$^\omega$ windings of R^1, and is thus heard by the "A" operator, warning her not to pass her demand until the tone has ceased. Relay *NS* operates,



NOTES.

1. Similar Relays in similar circuits are indicated by a common letter; thus the line relays in each O.W will be R relays.

2. A particular relay is indicated by associating with the common letter an index number of the circuit with which the relay is connected. Thus R^3 indicates the line relay in the 3rd order wire. A common relay will therefore have no such index.

3. A set of contacts of a relay is indicated by the letter and index of the relay and the designation number of the contacts; thus $S^1 5$ indicates the 5th set of contacts of relay S in the 1st order wire circuit.

3.—SPLIT ORDER WIRE WORKING. CIRCUIT ARRANGEMENT.

and if the special *NB* key is thrown contacts *NS*1 complete the circuit of the the indicator *Q* and causes the position calling lamp to glow. The driving magnet circuit having been completed at $S^1$2, as explained above, the arms are stepped round from the bank contacts of Exchange W over those of *X*, *Y*, and *Z* until they reach the bank contacts of Exchange V. Immediately they make contact with these a circuit is completed from battery, *T*, *c* arm, bank contact, $S^1$1, C^1, transfer key and earth.

Relay *T* immediately operates; at contacts *T*1 the driving magnet circuit is broken, and the arms *a*, *b* and *c* are thus brought to rest on the bank contacts of the Exchange V order wire.

Relay C^1 operates; contacts $C^1$5 disconnect the busy tone, advising the "A" operator of access to the "B" position, and at the same time $C^1$1 and $C^1$2 connect the "A" operator to the "B" position. $C^1$3 disconnects *NS* and *NS*1 falling back allows *Q* to be restored (if the special *NB* key is thrown) by the depression of the resetting key; $C^1$4 disconnects the circuit of the Exchange V lamp, extinguishing the glow. The time taken for the arms *a*, *b*, and *c* to rotate from the bank contacts of Exchange W to those of Exchange V is about ¼ sec., and this is, therefore, the duration of the tone to the "A" operator, and also that of the glow of the Exchange V lamp. This glow is really a flash, but it indicates to the "B" operator which exchange is calling, and she can at once select an idle junction from that exchange in readiness for the "A" operator's demand.

Suppose whilst the "B" operator is dealing with this demand another "A" operator comes on the Exchange V order wire, and also an "A" operator comes on one of the other order wires, say that from Exchange X. The second operator coming on the order wire from Exchange V does not alter the circuit conditions at the incoming end as regards this order wire, but the operator coming on the Exchange X order wire causes the *R* relay of that order wire, *i.e.* R^3, to operate, which in turn operates S^3 and the tone is sent out to the "A" operator due to the closing of contacts $S^3$5. The lamp of Exchange X glows in virtue of contacts $S^3$4 and $C^3$4 respectively being closed. As, however, the *T* relay is already operated, the closing of $S^3$2 has no effect on the driving magnet, as its circuit is open at *T*1, and as the arms of the rotary switch are thus stationary on the bank contacts of Exchange V, the closing of the $S^3$1 contacts has no effect on the relay C^3, which therefore remains unoperated. The tone on this order wire and the glowing of the lamp continue as their respective circuits are maintained at $C^3$5 and $C^3$4.

The first operator at Exchange V now leaves the order wire, but R^1 continues to be operated as the second operator is depressing the order wire key. The "B" operator having just dealt with a call from

Exchange V and seeing another lamp glowing momentarily actuates the transfer key. The throwing of the key first puts earth on the intermediate contacts of the *c* bank, and then breaks the circuit of the *C* relays and *T* relay.

Relay C^1 falls back, and contacts $C^1 5$ complete the tone circuit of Exchange V order wire, advising the operator on this order wire to wait until she is again connected to the "B" operator; $C^1 1$ and $C^1 2$ fall back; $C^1 4$ completes the circuit of the Exchange V lamp.

Relay *T* falls back, and the driving magnet circuit is completed in virtue of $S^3 2$ contacts being operated, and the arms *a*, *b* and *c* are stepped to the next contacts. Immediately these are reached, the *T* relay circuit is completed from battery through *T*, *c* arm, bank contact, transfer key to earth, and *T* is again operated, breaking the driving magnet circuit, and bringing the arms *a*, *b* and *c* to rest on the contacts intermediate to those of Exchanges V and W. The time occupied up to this point from the depression of the transfer key is approximately $\frac{1}{30}$ sec.

The transfer key is now released, and first connects earth to the *C* relays and then breaks the circuit of relay *T*. This relay falls back and again completes the circuit of the driving magnet. The arms *a*, *b*, *c* are stepped round until, reaching the contacts of Exchange X, the circuit of *T* relay and C^3 relay is completed over the *c* arm and through the transfer key. Relay *T* operates, and, breaking the driving magnet at $T1$, brings the arms to rest at Exchange X contacts.

Relay C^3 operates, and at $C^3 5$ removes the tone from Exchange X order wire, at the same time connecting this order wire to the "B" operator at $C^3 1$ and $C^3 2$; the opening of the $C^3 4$ contacts extinguish Exchange X lamp. A call can now be received from this exchange.

It will be noticed that from the time the transfer key is depressed relay C^1 has remained unoperated, and hence the tone continues on Exchange V order wire and the lamp continues to glow.

If an order wire becomes faulty beyond the "B" position, the two plugs of a double-ended cord are inserted into jacks J_1 and J_2, thus cutting out the faulty line and connecting one of the junctions to the automatic apparatus in its place.

THE NUMBER OF SELECTORS IN AUTOMATIC TELEPHONE SYSTEMS.

A THEORETICAL INVESTIGATION.

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THE following investigations into the capacity of the single switches in automatic telephone exchanges have been carried out with the idea of building up a scheme by means of which the required number of switches can be obtained with simple calculation.

From the fact that the results are represented graphically the investigation will perhaps have a wider interest. With the help of the curves shown it will be easy to calculate the capacity of one system or to compare the capacities of different systems.

The basis of the procedure can be represented as follows (fig. 1).

Suppose that C is a junction point (automatic or manual). From A the total number of simultaneous conversations are carried in a cable with x pairs to C. From this point the conversations are distributed to the 10 points B. For this purpose, cables with x_1, x_2, x_3 . . . x_{10} pairs are run from C to B_1, B_2, B_3 . . . B_{10}.

Assume that x is sufficiently large to carry the traffic from A to C, then it is clear, that

$$x_1 + x_2 + x_3 + \quad . \quad . \quad . \quad + x_{10}$$

must be greater than x, if it is required that each cable C–B shall carry the conversations which have to run through it with the same factor of safety against overloading, as the main cable A–C. The partition of the conversations between the cables C–B is, as it will be seen, in each moment subject to the law of chance.

By a careful study of the traffic conditions we are able in most actual cases to determine beforehand what fraction of the traffic each branch must carry on the average. But such calculations can only give mean values and the number of conversations on any branch may at particular times greatly exceed the mean.

In order to calculate the necessary number of conductors in a cable or group of circuits, especially having regard to a suitable factor of safety, we must employ the laws for the calculation of probabilities. This method of calculation has already been employed for other branches of telephony by *Fr. Johannsen*, managing director of the "Kjϕbenhavns Telefon-Aktieselskab." From one of his papers * I take the mathematical basis of the following discussion.

It should first be mentioned that for all calculations the most unfavourable time of day, usually the busy hour, must be used as a basis. The capacity of a group of conductors depends not only on the number, but also on the duration of conversations. The product of these two factors, the "Speech-minutes" will in the following explanations be represented shortly by *Sm*. As the most countings for statistic purposes are based on the hour, it is recommended that also *Sm* be specified for the hour. If we have a group of conductors which we wish to carry 1000 conversations each of 2 minutes duration in the busy hour, we must make our calculations with $Sm = 2000$. In each single moment of this hour there will exist $\frac{Sm}{60}$ connections on an average.

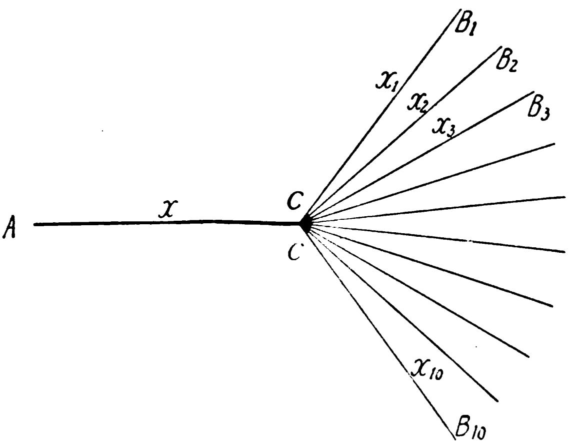

FIG. 1.

If there were absolute uniformity we should succeed with a number of conductors:

$$y = \frac{Sm}{60}.$$

Within the hour, however, the conversations are not distributed uniformly. The number of existing connections at each minute will vary on either side of the mean value y. If the variations are only the result of chance—and within the same hour this is tolerably correct—the average deviation will be $= \sqrt{y}$ (the law of square roots).

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* *Fr. Johannsen*, "Telephone Management in Large Cities," 'P. O. E. E. J.,' October, 1910, and January, 1911.

We must therefore have more than y conductors, and we take a group of conductors with a magnitude x, which can carry $y + n \sqrt{y}$ simultaneous conversations. The larger we choose n, the smaller is the probability of all conductors being simultaneously engaged. This probability will be—from the general exponential law of error—

16 per cent. for $n = 1$.
2·3 ,, ,, $n = 2$.
0·13 ,, ,, $n = 3$.

For the actual case and for the small values of y with which we have to deal, the law of error referred to must, however, undergo a correction, since n with decreasing values of y does not remain constant, but increases somewhat, as is seen from Table I.

The tables below showing the dependence between n and y respectively x and y, have been worked out by *A. K. Erlang*, scientific investigator of our company.*

TABLE I.—*n dependent on y.*

	1 °/oo.	2 °/oo.	3 °/oo.	4 °/oo.
$y = 1$	4·74	4·32	4·13	3·97
$= 2$	4·28	3·96	3·75	3·61
$= 3$	4·08	3·78	3·58	3·44
$= 4$	3·97	3·65	3·48	3·39
$= 5$	3·88	3·58	3·41	3·28
$= 10$	3·66	3·39	3·22	3·10
$= 15$	3·58	3·30	3·14	3·04
$= 20$	3·53	3·26	3·11	2·99
$= 40$	3·38	3·15	2·99	2·88
$= 60$	3·34	3·10	2·95	2·84
$= 80$	3·30	3·08	2·93	2·82

TABLE II.—*x dependent on y.*

	1 °/oo.	2 °/oo.	3 °/oo.	4 °/oo.
$y = 1$	5·74	5·32	5·13	4·97
$= 2$	8·06	7·60	7·30	7·10
$= 3$	10·07	9·55	9·20	8·96
$= 4$	11·92	11·30	10·96	10·70
$= 5$	13·68	13·01	12·63	12·34
$= 10$	21·58	20·70	20·18	19·80
$= 15$	28·87	27·77	27·15	26·78
$= 20$	35·80	34·60	33·88	33·38
$= 40$	61·37	59·90	58·90	58·20
$= 60$	85·90	84·00	82·82	82·00
$= 80$	109·50	107·60	106.20	105·20

The tables are calculated for the probabilities 1, 2, 3 and 4 per thousand, *i. e.* of 1000 calls 1, 2, 3 and 4 calls respectively will find all conductors engaged. The curves in figure 2, 3, 4 and 5 are drawn for 1 and 4 per thousand. The following calculations and examples relate only to the "1 per thousand" curves, since

one busy in 1000 calls

appears a satisfactory performance of a group of conductors or an exchange system.

As y increases n approaches a limit, at which it remains constant, when $y = 80$, $n = 3·3$, and for larger values we can reckon that

$$x = y + 3·3 \sqrt{y}.$$

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* See also *Bortkewitsch*, "Das Gesetz der kleinen Zahlen."

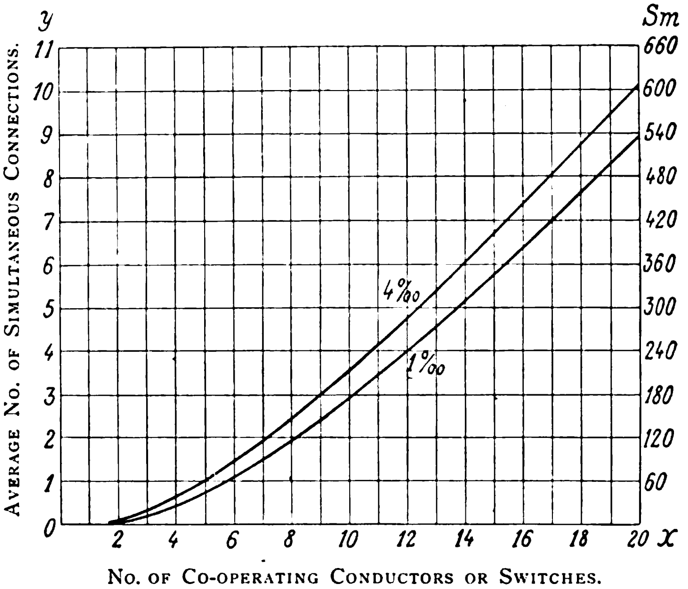

FIG. 2.

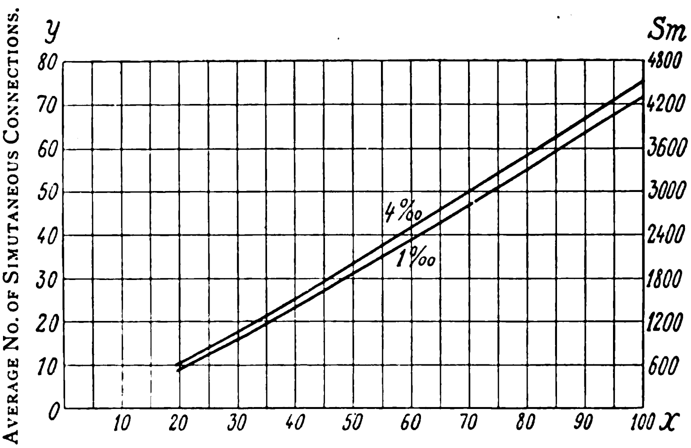

FIG. 3.

The curves in figs. 2 and 3 show for smaller values the corresponding values of y and x, fig. 2 showing the values for $x = 1$ to 20, and fig. 3 for $x = 20$ to 100 conductors. The ordinates on the right hand side of the curves give $Sm = 60\,y$.

In the curves of figs. 4 and 5 the abscissæ are the same as in figs. 2 and 3; but the ordinates give the magnitudes

$$u = \frac{Sm}{x},$$

i.e. for Sm "Speech-minutes" and x conductors in a group, each

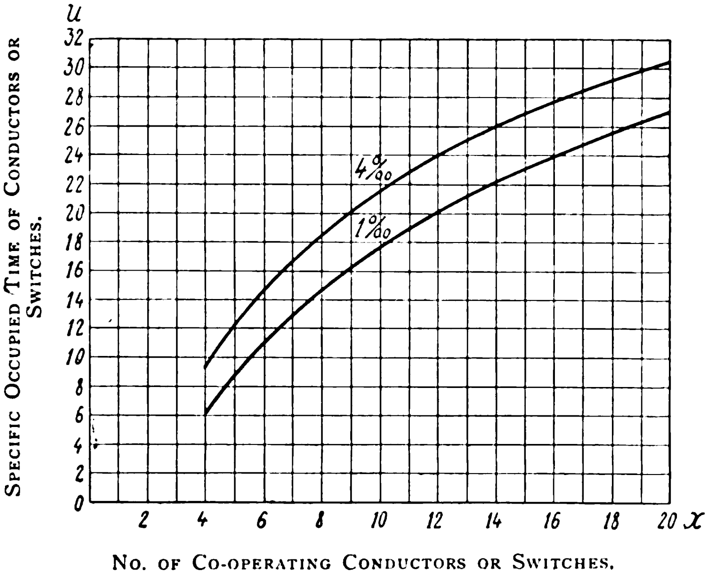

Fig. 4.

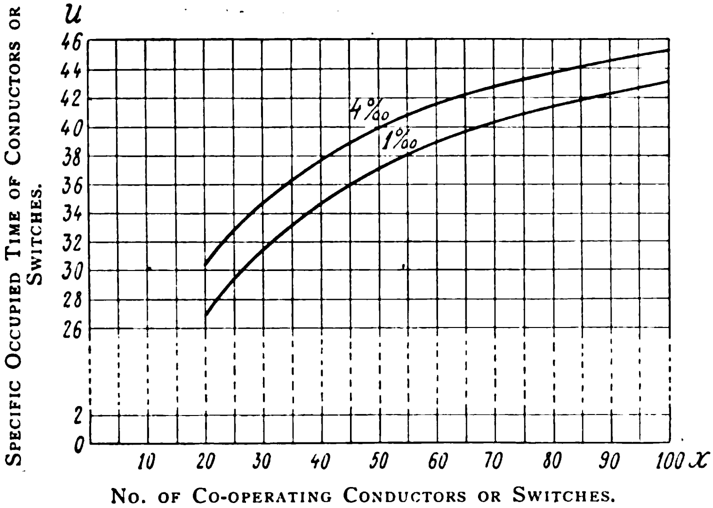

Fig. 5.

conductor is in use for *u* minutes in one hour. We shall call *u* the "specific occupied time."

The occupation "*a*" of each conductor is obtained by dividing *u* by 60:

$$a = \frac{u}{60} = \frac{Sm}{60\,x} = \frac{y}{x}.$$

The curves of figs. 2 to 5 form a very useful means for determining the number of conductors required in a group.

As an example we will calculate the case of fig. 1. Let $Sm = 4300$ for the length A–C. From the curve of fig. 3 we see that the number of necessary conductors $x = 100$. If for simplicity we suppose that all conversations are distributed uniformly over all the lengths C–B, Sm on each length will be 430. From the curve of fig. 2 we find $x_1 = x_2 = x_3 \ . \ . \ . = x_{10} = 17$. While, therefore, 100 pairs of wires suffice to carry the conversations from A to C, $10 \times 17 = 170$ pairs of wires are necessary to carry these same conversations on to the 10 points B.

If the distribution is non-uniform over the ten lengths C–B, the method of procedure is just the same; for instance, if $Sm = 180$ and 540 respectively for the two lengths C–B_1 and C–B_2, x_1 would be 10 and x_2 would be 20.

What is said here about conductors (pairs of wires) holds without alteration for **the selectors in an automatic system**, when it is demanded that the necessary selectors for each call shall be at hand without any waiting time.* In that case "C" in fig. 1 represents a group of selectors, and the conductors coming from A are connected to the movable parts of the selectors; from the multiple arcs of the selectors groups of conductors go to movable parts of the various sets of selectors (usually 10) of the next group. Mostly are the groups of conductors both for the length A–C and the lengths C–B divided into several smaller groups. These we shall call "teams" of conductors (compare: "team work") and attach to this term the following significance: The pairs of wires in a team are so interrelated that a call which seeks to find a path over one pair, but finds it busy, immediately seeks another pair of the same team. Pairs of wires in different teams cannot replace one another, and for the call referred to it is of no importance if free pairs exist in another team of the same group of conductors.

In order to appreciate the importance of this splitting into teams we will make use of fig. 2. A group of 20 conductors which is not subdivided can carry an $Sm = 540$, while the same group, divided into two distinct teams of 10, can only carry an $Sm = 2 \times 180 = 360$.

In systems where each arc of the selector multiple contains 10 contacts, the size of the teams is 10. If we assume in the above example that C in fig. 1 is the first selectors' group and B are the second selectors of such a system, we cannot be content with $x_1 = 17$. Since the size of the team is 10 ($Sm = 180$), we must have a number

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* By some systems, especially the machine switching systems (Lorrimer, Western Electric Co.), a waiting time may be allowed in certain selector groups. These investigations do not hold for such systems, but the saving of selectors which can be obtained can be figured out by a further treatment on the basis given in this paper.

$x_1 = 10 \times \frac{430}{180} = 24$, in order to allow of an $Sm = 430$. The 100 pairs of wires, which in one team carry an $Sm = 4300$ to the 100 first selectors, therefore require in fact $10 \times 24 = 240$ pairs of wires in order to carry the same "Speech-minutes" after 10 divisions of the second selectors.

If the selectors were provided with 17, instead of 10 contacts in the multiple arcs (team = 17), only 170 second selectors would be necessary in the same example. With a larger number of contacts can a correspondingly higher capacity of selector be attained. (Whether the plan is more economical on that account depends upon the rise in the price of the selectors.) Where several exchanges are concerned, the capacity of the junctions also increases with the number of contacts.

The method of calculation dealt with above can also be employed without addition for the calculation, as well of pre-selectors and call-seekers as of connectors. If, for example, in the Strowger system each of 100 subscribers is called once in the busy hour and the holding time is 1·5 minutes, then $Sm = 150$ for this group of subscribers. From the curve of fig. 2 it is seen that in this case 9 connectors are sufficient for every 100 subscribers.

We will now consider the curves of figs. 4 and 5. The ordinates u represent, as already explained, the specific occupied time of the conductors or selectors. This magnitude depends on the design of the selectors and forms a very serviceable means of calculating the necessary number of selectors when the "Speech-minutes" (Sm) of the exchange and the number of contacts in the selector arcs (*i. e.* the size of the team) are known. Thus the number of selectors in a group is:

$$N = \frac{Sm}{u}$$

if Sm is simultaneous "Speech-minutes" per busy hour for the whole system, and u the specific occupied time for a single selector of the group of the design under consideration.

We must remember here that the specific occupied time of the selector in a group is generally determined by the number of contacts on the selectors' arcs in the preceding group. If, then, the abscissæ x of the curves of figs. 4 and 5 represent the number of contacts of one selector group, the ordinates u give the specific occupied time for single selectors in the next group. If, for example, the first selectors have 10 (or 20) contacts in each arc, the specific occupied time for the second selectors will be $u = 18$ (or $u = 27$); the number of second selectors will then be:

$$N = \frac{Sm}{18} \left(\text{or } N = \frac{Sm}{27}\right).$$

It may be remarked here that the combinations of first and second pre-selectors, which, according to reports in the journals, are being employed in the latest exchanges of Siemens and Halske, act, in this connection, as pre-selectors with 100 contacts. The first selectors have, then, the very high specific occupied time $u = 43$. By the employment of intermediate selectors a similar specific occupied time for second and third selectors could be obtained in large exchanges.

Several automatic systems employ the so-called "call seekers" in place of pre-selectors; since such work in the reverse way from the group selectors, in that they seek out calling lines, the specific occupied time cannot be deduced directly from fig. 4. We must first determine from fig. 2 the number x of call seekers in team for a given group of subscribers; then we find the corresponding occupied time from fig. 4. If, for example, the call seekers contain 100 contacts in the arc while each subscriber calls 1·5 times in the busy hour, and the average holding time is 2 minutes, 100 subscribers must be multiplied to a number of call seekers; for these 100 subscribers $Sm = 100 \times 1{\cdot}5 \times 2 = 300$, and from fig. 2 we find the team $x = 14$. For every 100 subscribers, therefore, must 14 call seekers be provided; from the curve of fig. 4 we read that each call seeker has a specific occupied time, $u = 22$ minutes. The number of call seekers in the whole exchange must then be:

$$N = \frac{Sm}{22}.$$

With a small Sm it may happen that the calculated value of $N = \frac{Sm}{u}$ is smaller than the number of contacts in the arcs of the preceding selector group. There is, then, a team not fully loaded, which is not sufficiently used, and we must deduce the number $N = x$ from fig. 2. If, for example, in a Strowger exchange we determine the number of connectors and find in this exchange that for 100 subscribers $Sm = 120$, we find from the formula:

$$N = \frac{Sm}{u} = \frac{120}{18} = 6,7 \sim 7.$$

This number is, nevertheless, too small, and we must obtain from fig. 2 the number $N = x = 8$.

As an example calculations will be given here for a Strowger exchange with Siemens and Halske first and second pre-selectors.

Assume: An isolated exchange with 4000 subscribers; each subscriber calls on an average 8 times in the whole day and once in the busy hour; holding time, 1·5 minutes.

For the whole exchange the busy hour:

$$Sm = 1{\cdot}5 \times 1 \times 4000 = 6000.$$

(1) First pre-selectors. $N = 4000$.

(2) Second pre-selectors. Size of team between first and second pre-selectors $x = 10$; for the second pre-selectors $u = 18$.

$$N = \frac{6000}{18} = 333.$$

(3) First selectors. Size of team between second pre-selectors and first selectors $x = 100$; for the first selectors $u = 43$.

$$N = \frac{6000}{43} = 140.$$

(4) Second selectors. Size of team between first and second selectors $x = 10$; for the second selectors $u = 18$.

$$N = \frac{6000}{18} = 333.$$

(5) Connectors. These are divided into 40 groups, each for 100 subscribers. For 100 subscribers $Sm = 150$. From figs. 2 and 4 we deduce $x = 9$ and $u = 16{\cdot}7$.

$$N = \frac{6000}{16{\cdot}7} = 360.$$

The following numbers and occupied times of selectors in this exchange may be of interest:

	Number.	Specific occupied time per busy hour.	Specific occupied time per day.
First pre-selectors	4000	1·5 min.	12 min.
Second ,,	333	18 ,,	2 hrs. 24 ,,
First selectors	140	43 ,,	5 ,, 44 ,,
Second ,,	333	18 ,,	2 ,, 24 ,,
Connectors	360	16·7 ,,	2 ,, 13 ,,

In this example it was reckoned, for simplicity, that the traffic is uniformly divided between different hundreds or thousands. If this is not the case the calculation must be subdivided and the particular value of *Sm* for each division must be taken into consideration.

Just as we have found the capacity of single selectors the capacity of a whole exchange may here be discussed briefly. This capacity is best expressed by *Sm*.* When *Sm* is the same for

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* In technical writings the capacity, *i. e.* the possible number of simultaneous connections, is sometimes given as a percentage of the number of subscribers, the number of first selectors being the basis. Thus, in the above example the percentage capacity—

$$p = \frac{140 \times 100}{4000} = 3{\cdot}5 \text{ per cent.}$$

Without second pre-selectors 333 first selectors would be necessary, which in the same way corresponds to a percentage capacity—

$$p = \frac{333 \times 100}{4000} = 8{\cdot}3 \text{ per cent.}$$

although the capacity of the exchange is the same. In this case there is no agreement between the statement and the actual capacity.

two exchanges of different design the exchanges may have the same capacity; of course it is assumed that both exchanges are calculated for the same factor of safety (*e. g.*, 1 per thousand in each group of selectors). Further magnitude $y = \frac{Sm}{60}$, which is the average number of simultaneous connections, is suitable as a measure of the capacity. Thus for the exchange of the example $Sm = 6000$ and $y = 100$.

In these calculations we have assumed a safety factor of 1 per thousand; it means that of 1000 calls one call is to be reckoned as lost in each selector group. In a five-figure Strowger system there are five selector groups, and 5 calls in every 1000 will be non-effective. If second pre-selectors are employed there will be 6 non-effective calls. In a development of this system for six digits there will be 6 or 7 lost calls. The total safety factor of the exchange, therefore, diminishes with increasing numbers of selector groups (2, 3, 4 per thousand, and so on). In this respect systems with fewer selector groups are better than those with more selector groups.

If we wrote a specification according to the preceding explanation for the exchange of the example, it would read approximately:

Number of subscribers	4000
Sm for the busy hour	6000
Lost calls per 1000	5

It is not necessary, however, to provide for the same safety factor in the various groups. Ample provision in this direction costs money, but it does not cost the same in the various groups. If in the above example the first selectors are calculated with the safety factor 4 instead of 1 per thousand, 133 selectors instead of 140 would be necessary. The saving will, therefore, only be 5 per cent. In the connector groups, on the other hand, we can come down from 333 to 272 switches, *i. e.* a saving of 18 per cent.

The number of switches calculated in the manner indicated above can be changed somewhat to meet actual local conditions. Opinions regarding the chosen factor of safety are probably very various. However, the calculations give the relative conditions, and it will be easy for any desired factor of safety to calculate the scheme in accordance with the principles laid down.

In this representation it is assumed that the size of the team is the same as the number of contacts in each arc of the switches. It should, however, be pointed out that one is not precluded, by means of suitable multiple connections, from obtaining an effective team somewhat greater than the number of contacts. In this case one must simply work with this "apparent number of contacts." (See, for example, the second pre-selectors of Siemens and Halske).

SUMMARY.

It is shown how one can estimate from simple formulæ or curves the number of selectors in the various groups, under the assumption that in each group a definite pre-determined safety factor of "busy groups" is obtained. On the same curves is shown the influence of the number of contacts in the selector arc and the capacity of switches of different construction can be easily deduced.

Lastly, a general statement of the capacity of a whole exchange is obtained.

AN ARTIFICIAL EQUIVALENT OF AN OPEN-WIRE LINE FOR TELEPHONIC EXPERIMENTS.

By G. M. B. SHEPHERD.

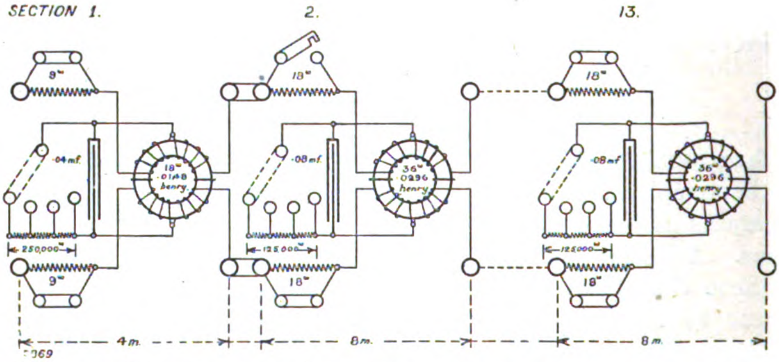
ARTIFICIAL cables are now a common and necessary adjunct to the telephone testing room and research laboratory, and such apparatus is commercially obtainable in a variety of convenient forms. Artificial open-wire lines are, however, less common, and of those that have come within the writer's survey, few, if any, appear to be really satisfactory reproductions of the properties of the open-wire trunk circuit. Inductance has frequently been ignored altogether, whilst precautions to ensure that the four line constants should be reasonably correct under telephonic conditions were conspicuously absent. It may therefore, perhaps, be of interest to describe the design of, and tests upon, an artificial line of this type that has recently been constructed by the G.P.O. for telephonic research work, and which would seem to embody features of a more elaborate kind than have been attempted hitherto.

DESIGN.—In designing this apparatus, two points were kept particularly in view; first, that the line constants should not be liable to serious change as higher frequencies of the voice are approached; and second, that the sub-divisions should be small enough to permit of experiments with loading coils. Some means of varying the leakance, and of imitating two gauges of line by an easy adjustment, was also desired. It was of course important to keep within reasonable dimensions, but at the same time to ensure that coils, etc., should not inductively interfere with one another. Shielding of any sort was not thought expedient, being likely to bring about increases in effective resistance with frequency.

The conducters imitated are 200 and 400 lbs. H.D. copper (112 and 158 mils diameter) having nominally the following constants per loop mile:—

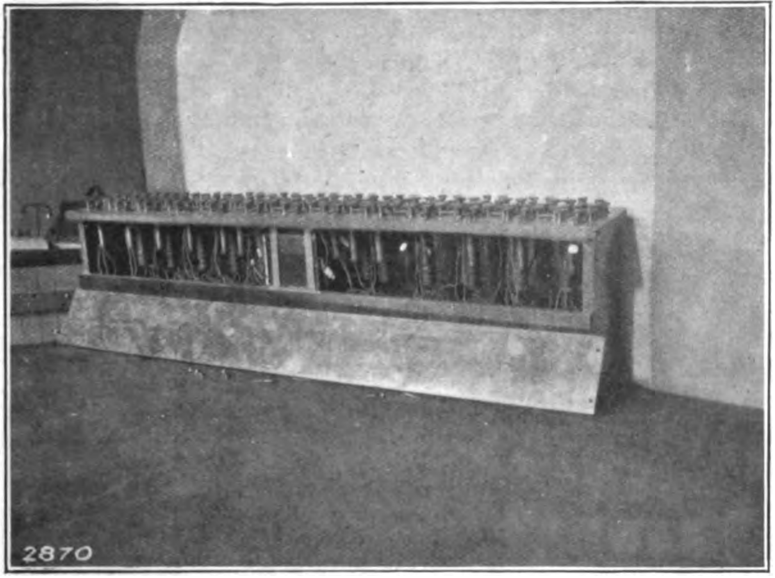
	200-lbs.	400-lbs.
R =	9^{ω}	$4{\cdot}5^{\omega}$
K =	·01 m.f.	
L =	3·7 m.h.	

Leakance (S), so far as direct current measurement is concerned, was to be adjustable to the values zero (actually about ·005) 1, 2 and 10 micromhos per mile. Theoretically there should, of course, be a small difference in the constants K and L for the two wire gauges, but in consideration of the larger variations in practice due to uncertain factors, it was not thought worth all the additional complexity to reproduce it.



I.—Internal Connections of Apparatus designed for use as an Artificial Equivalent of an Open Wire Line.

The line comprises 200 miles of loop circuit, and the arrangement is shown diagrammatically in **1**. It is what Prof. Kennelly would term a "nominal T" line, *i.e.*, the series and shunt impedances of the section are those of the length of line represented, and are not corrected for lumpiness. The T is quite symmetrical for the 400 lbs. conductor, but additional non-inductive resistances are thrown in on one side only of the inductances when 200 lbs. is imitated. There are twenty-six sections in all, contained in two cases, approximately 37 in. × 7 in. × 10 in., one of which is depicted in **2**. Each section contains a mica condenser, inductive coil with two windings, a leak coil, and the extra non-inductive resistances to give the change of gauge—other things remaining the same. There are twenty-four sections equivalent to eight miles of line, and two of four miles, this arrangement being adopted to meet the prevailing loading coil spacing practice for open wires. The inductive coils, which were manufactured by the Western Electric Company, have a total inductance of about ·03 henry, and by themselves furnish just the resistance required for the 400 lb. conducter. They are wooden core toroids of nearly the same dimensions as the loading coils commonly used for underground cables. There are two windings on opposite halves of the ring, the middle point of each being brought out and connected to the capacity, etc., as shown in **1.** The toroidal form was selected because of its comparatively small external field—an important matter where a number of such coils have to be packed into a limited space. As a further precaution the coils, which are located in the lower portion of the boxes, are placed alternately at right angles, and held in position by a filling in of wax. It was found even with this arrangement that an appreciable amount of mutual induction existed between some pairs of coils, and this was abolished by adjusting each in turn relatively to its neighbour under a strong tone test, prior to pouring in the wax. The condensers, of which there are thirteen in each 100-mile box, are mounted up together in a tin case, with a tin division-plate between each.



2.—General View of "100 Mile" Case.

The leak resistances required special consideration, as single spools of the magnitude of 125,000$^{\omega}$ and 250,000$^{\omega}$ which were needed to imitate a wire-to-wire insulation of 1 megohm per mile, are capable of giving a good deal of capacity reactance at speech frequencies. After some experimenting, it was found that a "hurdle" spool consisting of a wood bobbin 4 in. long and $\frac{7}{8}$ in. diameter, with ten narrow channels to take No. 46 Eureka wire, would meet requirements. The wire is wound *inductively*, and the ten sections connected up alternately in reverse directions. By this means, it was found possible to reduce the reactance to a figure affecting the attenuation constant of the line by less than $\frac{1}{10}$th per cent. even at 1,000 periods per second. Two intermediate points, as shown in **1**, are tapped out to furnish leak resistances equivalent to 0·5 and 0·1 megohm per mile.

The external connectors are of a simple kind, consisting only of substantial terminals and straps; no switches are fitted. The general assembly and wiring calls for little comment save that it was a job necessitating some care. It was found desirable to arrange for the sides of the cases to be removable, rather than employ any slack wire or hinged cabling beneath the terminal board. Some trouble was experienced initially from low D.C. insulation, which was located to surface leakage on the under side of the ebonite covers. This was got rid of by drying out and treating with paraffin wax.

SPEAKING TESTS.—A series of speaking tests on the complete 200 mile circuit was carried out to determine its standard cable equivalents. The artificial open-wire line was connected between two fairly long lengths of cable, and the reflection losses (or gains) at each junction duly allowed for in comparing the measured with the calculated equivalent in standard 20 lb. cable. These results are entered in Table A.

TABLE A.

Weight of conductor. lbs.	D.C. insulation per mile.	Standard cable equivalent.			Attenuation α for 800 ~.
		Observed.	Computed for 800 ~.	Computed for 900 ~.	
200	200 Ω	12·2 m.	12·7 m.	12 m.	·00717
,,	0·5 ,,	13·4 ,,	13·9 ,,	13·2 ,,	·0078
,,	0·1 ,,	17·2 ,,	18·3 ,,	17·3 ,,	·0103
400	200 ,,	5·4 ,,	5·9 ,,	5·5 ,,	·00365
,,	1 ,,	5·6 ,,	6·4 ,,	6 ,,	·00395
,,	0·5 ,,	6·7 ,,	7 ,,	6·5 ,,	·00425
,,	0·1 ,,	10·8 ,,	11·3 ,,	10·6 ,,	·00673

The agreement between measurement and calculation is seen to be very good, especially when that rather mythical quantity the "equivalent mean frequency of speech" is taken to be 900 periods instead of 800 periods. There are at present good reasons for believing that this number is over, rather than under 800, though the latter is a very suitable working figure for many purposes. The absence of distortion was very noticeable when the larger leakances were introduced.

A.C. MEASUREMENTS.—The line and attenuation constants for single frequency currents were determined from the open and closed end impedances by two different methods. The first was by the agency of the Franke machine described in 'The Electrician' of October 24th, 1913.* The second was a bridge test, the arrangement of which, and the specially designed resistances and condensers, are due to the writer's colleague, Mr. Charles E. Hay. Both methods have been described before, and lead to the same end, viz. an accurate measurement of the vector sending end impedance of the line, when the distant end is either open or short-circuited. Most of the tests were made at 800 periods with sinusoidal current not exceeding 2 or 3 m.a. at the sending end, and sometimes considerably smaller—quite of telephonic order. The length of circuit operated upon was 100 and 200 miles, with the various modifications as to leakage, etc., that the apparatus was capable of reproducing. Table B gives a summary of the results, each figure being a mean of two or more determinations by one or both of the aforesaid methods.

TABLE B.

D.C. insulation per mile.	~	200 lbs.					400-lbs.				
		R ohms.	*L* m.h.	*K* m.f.	*S* mmho	*a*	*R* ohms.	*L* m.h.	*K* m.f.	*S* mmho.	*a*
200 Ω	800	8·8	3·78	·010	0·63	·00717	4·2	3·81	·0101	1·11	·00371
1	800	8·67	3·74	·010	1·78	·00748	4·21	3·77	·00996	1·95	·00399
0·5	800	8·67	3·73	·0101	2·72	·00779	—	—	—	—	—
0·1	800	8·88	3·76	·00991	10·55	·0104	—	—	—	—	—
1	1600	8·15	3·72	·0099	3·53	·0077	—	—	—	—	—

Comparing these figures with the nominal constants already given, and the calculated attenuations in Table A, it is seen that on the whole there is little divergence. *R* is slightly lower, *K* and *L* practically unchanged, even at 1,600 periods. The normal leakance of the apparatus increases from a nominal D.C. value of 0·005 micromho to 0·63 micromho at 800 periods. This appears to be in part due to the non-uniform nature of the circuit, which also explains the apparent reduction in *R*, and also, no doubt, to the usual effects observed when condensers, etc., are subjected to frequencies of telephonic order. 0·63 mmho. means an $\frac{S}{K}$ of 63, which corresponds to the value actually observed on trunk lines during fine weather conditions (J. G. Hill, Inst. of P. O. E. E., January 12th, 1914). With the various added wire leakances, values of $\frac{S}{K}$ approximating to damp and very wet weather conditions, as observed at 800 periods, are obtainable. Prof. Kennelly describes similar measurements on an artificial open-wire line built up in 80 KM. sections (Am. I. E. E., June 24th, 1913), which show a drop in the effective R of some 400 *per cent.*, with a 10 per cent. fall in capacity, so that the results tabulated above do not afford much ground for complaint.

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* See also POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, October, 1912.

There is a point of mathematical interest in regard to the evaluation of Pl, the propagation length, from the expression—

$$Pl = \tanh^{-1} \sqrt{\frac{Z}{Z_f}};$$

due to the fact that $\tanh(x + jy) = \tanh(x + j(y + n\pi))$. The effect of this ambiguity in reversing the Hyp. tangent is that one cannot be quite sure of the imaginary part of Pl without some foreknowledge of the nature of the line, or the wave length. This may generally be inferred, but circumstances might conceivably occur that would render the matter very perplexing and undecided.

In conclusion, it may be said that the objects aimed at have been accomplished. It may later on be desirable to reproduce a greater length of circuit than 200 miles, but in such event it is probable that a simpler design will suffice, with a considerably larger degree of lumpiness. Apart from the question of loading and varying the leakage, there is reason to believe that a 20 m. section, duly corrected in accordance with Kennelly's equivalent line theory, would be sufficiently accurate for many experiments, and would obviously be a less bulky and complicated piece of apparatus.

PAPER-CORE TELEPHONE CABLES.

By S. Hanford, B.Sc.,
Test Section, E.-in-C.O.

Determination of Dimensions and Weight by means of Curves.

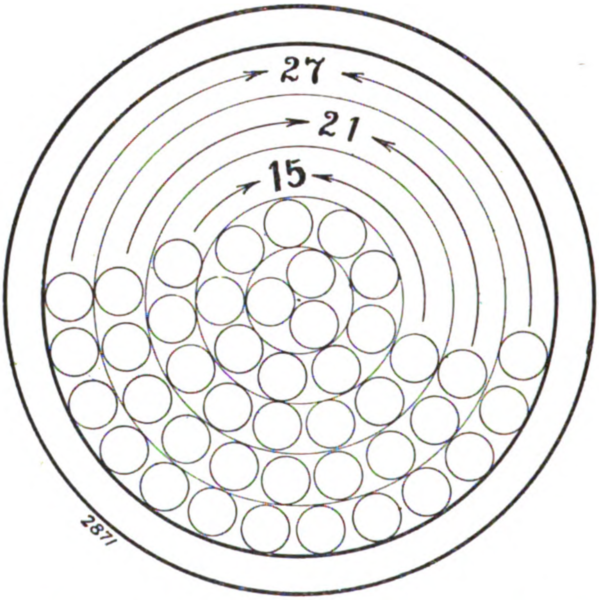
The method I am about to explain was the outcome of an endeavour to obtain a specification which would cover any size of 10, 20, and 40 lb. conductor cable, simple or composite, and so enable yearly contracts to be placed for junction and subscribers' cables without stating the particular types required when placing the order. It has since been extended to include 70, 100, 150, and 200 lb. conductors for cables containing trunk circuits.

One method of determining the size of core to be contained by the lead sheath is to consider each pair as (theoretically) a circular tube in the cable—a circle of a certain diameter for a given size of conductor, giving a certain wire-to-wire capacity. From experience the diameters of these theoretical circles and the capacities which correspond may be obtained, and by consulting a table of such relations the correct "diameter of a pair" for the required standard capacity could be ascertained.

The size of the circle representing a pair being thus determined, it is necessary to arrange them in layers, the number of circles being equal to the number of pairs required in the cable. Owing to the fact that the pairs are stranded—*i.e.* the pairs in each layer form spirals round the layers beneath, alternately right- and left-handed in the succeeding layers—the cross-section (theoretical) of a cable would show these tubular pairs as ellipses. In order to allow for this it is usual to reckon that in any layer there will be six more pairs than in the layer beneath, whereas if the pairs were not stranded seven pairs more would be possible every third or fourth layer. (An exception to this is the case of six pairs round a centre of one pair, when it is only possible to make an increase of five for the first layer.)

For example, 1 shows a theoretical representation of a 75-pair 20 lb. cable. The "diameter" of each pair is ·132 in., and it is easily seen that if this dimension be represented by d', and the diameter of the stranded core by d, then $d = 8d' + 2{\cdot}15d'$, where $2{\cdot}15d'$ is the equivalent of a three-pair core, or $d = 10{\cdot}15d' = 1{\cdot}34$ in.

The maximum wire-to-wire capacity for such a core would be specified as ·060 microfarad per mile; two layers of paper would be wrapped round the core before the lead sheath of suitable thickness, depending on the size of core, were applied.



1.—Theoretical Representation of a 75-pair 20lb. Cable. Twice actual size.

In the case of composite cables containing two or more gauges of conductors, the sizes of the theoretical circles required for each size of conductor will be ascertained, and then the circles will be arranged in a similar manner, the largest size conductors in the centre layers, next the medium sizes, and the smallest in the outer layers. In this way a compact and round cable is produced, which for local work permits of the subscribers' circuits being jointed off without disturbing the heavier junction circuits beneath.

A certain amount of consideration will show that by this method it is difficult to express the size of core in terms of the number of pairs of different sizes of conductors to be contained in it without actually working out the sizes of all the cables required. If, however, we use as our starting point a standard amount of space for each pair, which may be calculated from the results of experience to give the required capacity, we have immediately a basis by the use of which the determination of the sizes of all cables may be reduced simply to the reading of a set of curves.

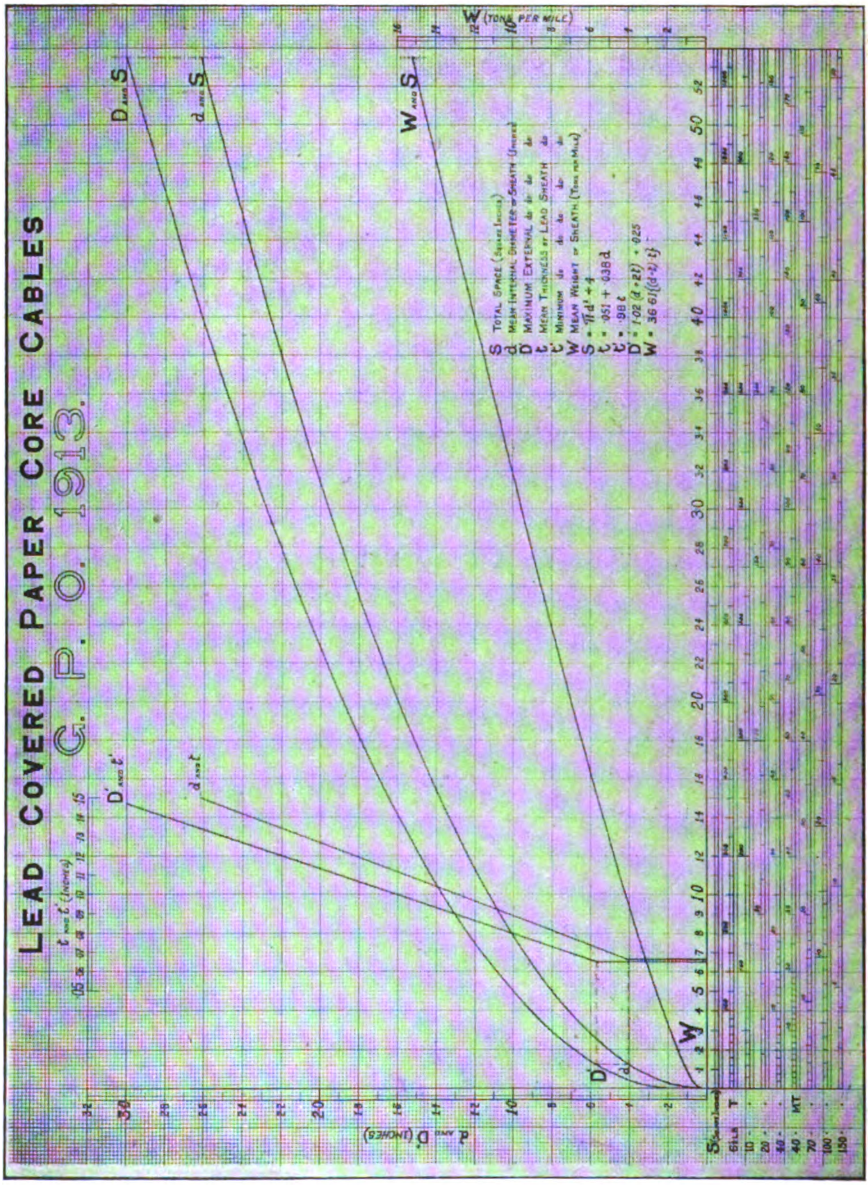
The spaces allowed per pair of conductors, based on the results of previous practice, together with the standard capacity at present specified by the Post Office, are shown in the following table.

Weight of conductors and type of cores.	Space per pair (square inches).	Specified capacity (microfarads per mile).
10 lb. twin	·006	Maximum not to exceed ·080
20 ,, ,, ...	·018	,, ,, ·060
40 ,, ,, ...	·040	,, ,, ·056
70 ,, ,, ...	·048	,, ,, ·065
40 ,, multiple twin .	·030	Mean ,, ·065
70 ,, ,, .	·045	,, ,, ·065
100 ,, ,, .	·068	,, ,, ·065
150 ,, ,, .	·105	,, ,, ·065
200 ,, ,, .	·145	,, ,, ·065
200 ,, ,, .	·125	,, ,, ·070

With the aid of this table we may now immediately determine the total space which will be occupied by the core of a cable by multiplying the number of pairs of each size by the relative space allowable per pair, and adding together the items so produced. For any one value of the total space there is one diameter of core given by the usual relation S (sq. ins.) $= \frac{\pi d^2}{4}$, where d = diameter of core in inches. This relation may be expressed by a parabola starting from the zero of both scales (see **2**, d and S).

For any given diameter a proportionate thickness of lead sheath is necessary. The relation may be expressed by a straight line on the graph. The equation at present being used for Post Office telephone cables is: $t = {\cdot}051 + {\cdot}038\,d$, all in inches (see **2**, d and t).

The external diameter of the lead sheath will be $D = d + 2t$, hence by adding twice the corresponding lead thickness to a reading on the curve for d we should obtain a relative D for a cable having a given total space. As the maximum allowable overall diameter is more important, however, especially in cases where duct-space is limited, a curve showing the corresponding values of D^1 (maximum overall) is more useful. The manufacturing allowance is 2 per cent. on the mean diameter (D) plus a constant allowance of ·025 in., which allows of a relatively greater increase in space, should a manufacturer require it for small cables, in which it is more difficult to obtain the required capacity with a given space per pair. Taking into account these allowances, $D' = 1{\cdot}02\,D + {\cdot}025$ in. $= 1{\cdot}02\,(d + 2\,t) + {\cdot}025$ in.



2.—Curves showing Relations of Space, Diameter, Lead Thickness, and Weight of Sheath.

This relation has been plotted and is shown on the graph as the larger parabola (see **2**, *D′* and *S*) and reading vertically above the total space required for the core, we at once obtain on this curve the maximum diameter in inches.

The minimum lead thickness allowed is 2 per cent. below the mean, so that a second straight line may be drawn which will represent the relation between the maximum overall diameter and the minimum lead thickness (see **2**, D' and t'). The least thickness of lead which will give satisfactory parallel jointing to large cables is stated to be ·065 in., so that the t' line becomes vertical at ·065 in., and the t line vertical at the corresponding value of ·0664 in.

The remaining curve marked "W and S" is included for convenience when calculating the approximate weight of a cable. As the thickness of lead is a simple function of the diameter of the core, the weight of lead sheath may be plotted as a function of the total space. The relation $W = 36{\cdot}61\ (d + t)\ (t)$ is used for determining the curve in conjunction with the known relation of d and S. The curve is a parabola with modification at the zero end accounted for by the adoption of the ·065 in. minimum lead thickness. The scale on the right indicates the tons per mile of lead sheath corresponding to the necessary total space previously determined.

A couple of examples will serve to explain more fully the use of the curves, and will show the rapidity with which the dimensions may be determined.

(1) Required the maximum diameter and minimum lead-thickness allowable, together with their mean values for cable, paper-core, twin, 75 pr/40 + 150 pr/10. Standard capacities.

Total space = 75 × (space per pair, 40 lb.) + 150 × (space per pair, 10 lb.)

= 75 × ·040 + 150 × ·006.

= 3·90 square inches.

Locate this on the horizontal scale immediately beneath the curves, and travel vertically above the point until the d and S curve is cut. The reading on the left-hand scale gives $d = 2{\cdot}23$ in. under the sheath. Proceed vertically until the D' and S curve is cut, and the corresponding reading on the left-hand scale gives $D' = 2{\cdot}575$ in.

From the points on the parabolas giving these readings, travel horizontally to the left until the curves of t and t' are cut. At the point where the t curve is cut by the imaginary horizontal from the d curve, read on the scale over the lead lines, and it gives $t = {\cdot}136$. Similarly at the point where the t' line is cut by the imaginary horizontal corresponding with D', reading on the top scale we have $t' = {\cdot}133$ in. Hence the required dimensions are:—

Maximum diameter overall . . .	2·575 in.
Minimum lead thickness . . .	·133 in.
Mean diameter overall ($D = d + 2\,t$) .	2·50 in.
Mean lead thickness	·136 in.

(2) Required the maximum diameter, and approximate weight of cable, paper-core, multiple twin, 6 pr/150 + 26 pr/70 + 44 pr/40.

Total space $= 6 \times \cdot105 + 26 \times \cdot045 + 44 \times \cdot030.$
$= 3\cdot12.$

From the D' and S curve, maximum diameter $= 2\cdot32$ in. Also from W and S curve, weight of sheath $= 9\cdot80$ tons per mile, to which must be added weight of copper (allow 2 per cent. for lay).

Copper weight $= \frac{(900 + 1820 + 1760) \, 2 \times 1\cdot02}{2240} = 4\cdot08$ tons per mile, and weight of paper and string (approximately $17\frac{1}{2}$ per cent. of copper) $= \cdot71$ tons per mile.

Total weight $14\cdot6$ tons per mile.

It must be borne in mind that the make-up of a cable must be such as to admit of its manufacture in reasonably complete layers. To revert to our original conception of a pair as a circular tube in the cable, let us consider the effect of having a cable made to this space basis in which the layers are not full. The leaving out of a number of pairs from each layer automatically decreases the total space allowable for the core, and yet there are the same number of layers as if the cable were compact. Each layer is squashed so that the theoretically circular tubes which represent pairs, of which a number have been left out of each layer, become theoretical elliptical tubes flattening in the direction of the radius of the cable, and spreading round to fill up the vacant spaces left in the layers. This alteration cannot be considered to go on to any great extent without affecting the wire-to-wire capacity. At present no cable is ordered in which the space allowable for the core is less than 85 per cent. of the space required for a compact core with an equal number of layers, or in which any layer has less than two-thirds of the total possible number of pairs. If the cable is multiple-twin it must be quite compact.

NEWPORT (MON.) AUTOMATIC AND DEVELOPMENT WORK.

ARMOURED CABLE ACROSS RIVER USK.

NEWPORT, (Mon.) is at present the scene of activity from a telephone engineering point of view, the work in hand comprising a new automatic exchange at the H.P.O., to which will be transferred the subscribers now working on the ex-National Telephone main Exchange at Dock Street, the Maindee sub-Exchange, and the H.P.O. local switch. Underground and overhead work in connection with the recently studied development scheme is also in progress.

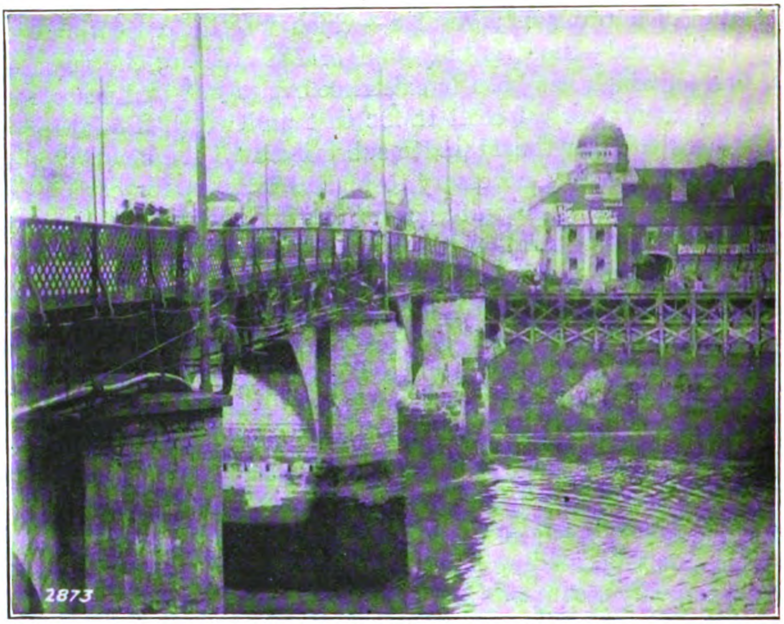
The Maindee Exchange serves the subscribers who are situated east of the River Usk, which runs through Newport. With the exception of a transporter bridge—which for the present purposes may be ignored—there is only one bridge crossing the river, and this bridge, which has been in existence over a hundred years, forms the main artery for all road traffic east and west. Following the decision to transfer the Maindee subscribers to the new Automatic Exchange, it became necessary to make provision for carrying the necessary number of circuits across the river. It should be mentioned that the Corporation has just obtained Parliamentary powers to construct a new bridge practically on the site of the existing one. Ordinary methods, *e.g.* underground, were ruled out as impracticable, and it was decided to effect the necessary link by means of an armoured cable fixed to the side of the bridge; owing to the shifting nature of the bed of the river a submarine cable was not recommended. Permission to use any portion of the iron superstructure of the bridge for supporting the cable could not be obtained, the Borough Engineer being of the opinion that the bridge is already carrying its maximum load. The method which was ultimately decided upon was to fix the cable to the stonework of the bridge by means of iron hangers, shewn in photo. **A** (left-hand side, near pier). A brief description of the actual cable-running operations may not be without general interest.

It was considered advisable to carry out the work during Sunday, and it was thought that with preparations made beforehand the cable could be run across in one day. Iron hangers capable of carrying two cables were made locally. The hangers and Lewis bolts for fixing were handed over to the Corporation, whose masons fixed them to the bridge, a stipulation made by the Borough Engineer. A scaffolding was also erected by the Corporation workmen from end to end of the bridge for the dual purpose of providing accommodation for the masons and the cabling operations. The erecting of the scaffolding and the fixing of the hangers occupied about three weeks.

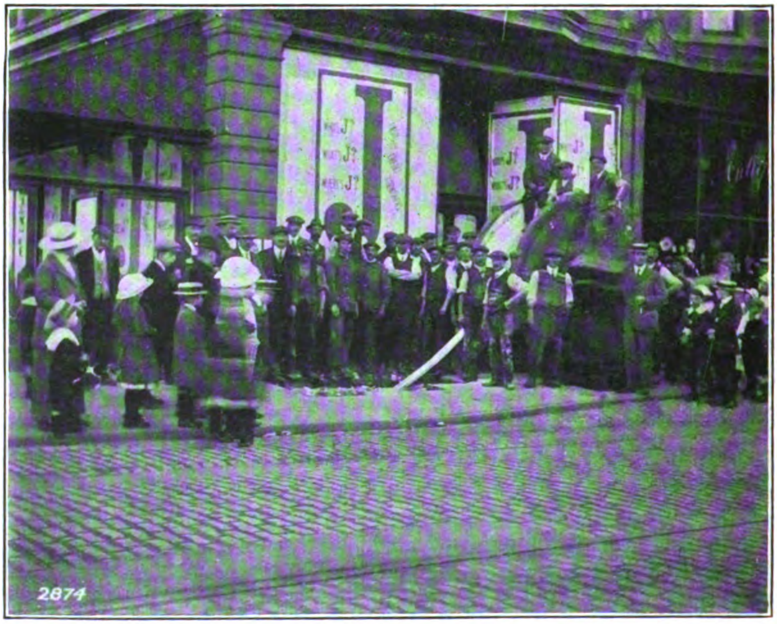
The method to be adopted required very careful planning owing to site difficulties and the fact that the cable would not lie in a straight line on account of the projecting iron-work on the bridge piers. Several suggestions were considered, the method ultimately decided upon being as follows:—

Four 400 lb. G.I. wires were run in each span, the wires being "made off" on the traction standards, one of which is fixed on each pier of the bridge. The ground on the west end of the bridge was opened, and an opening made in the bridge side wall for the purpose of leading out the cable from the footway to the underside of the bridge footway.

On the morning of July 11th the final preparations were made,



A.



B.

Running an Armoured Cable across the River Usk.

the hand winch was rigged up in a yard at the east end of the bridge, the hauling rope being paid out across the bridge and supported to the suspending wires by means of a few cable slings, and the whole of the tools, plant, etc., likely to be required were placed on site.

The preparations being complete there remained only the (mental) rehearsal of the following day's programme, and the careful testing and setting of alarm clocks, the work being timed to commence at 4 a.m.

The actual cabling operations were as follows:—The hauling rope was secured to the cable-grip and hauling commenced. As soon as a sufficient length of the cable had passed through the pavement the wire slings described below were placed in position on the cable and hitched on to the suspending wires. It should be mentioned here that it was found raw-hide slings would not carry the cable. A rough and ready, but nevertheless efficient, sling was devised, viz., two loose turns of 400 lb. G.I. wire wrapped round the cable, and suspending wires with twisted ends placed at intervals of about 4 feet. It was found that these slings "bit" on the tarred yarn covering of the cable to such an extent as to prevent slipping, and they maintained their relative positions throughout the length of the run for each span. As each sling approached the first traction standard it was unshipped and placed in position again as soon as the necessary length of cable had been run, and this process was repeated at each standard. Three men were thus employed on each pier—No. 1 "shouldered" the cable, the weight of which was then taken on a rope strop controlled by No. 2, standing on the bridge footway; No. 3 unshipped the G.I. wire sling and passed it across to No. 1, who replaced it after the position it had previously occupied had passed the standard.

As a precaution, and to prevent the cable end falling into the river in case of accident, two or three rope slings were placed in position in each span through which the cable end happened to be passing at the time. As soon as the cable had safely passed the next standard, these slings were removed and placed in position on the next span.

When the end of the cable arrived at the "winch" end of the bridge, it was realised that the "anxious" part of the work had been accomplished, but that the hard work was about to commence.

The reason for this will be seen by a reference to the photo. **A.** The portion of the cable nearest to the camera is shewn supported by the suspending wires and slings *outside* the ropes supporting the scaffolding. The cable had to be pulled *inside* the two sets of inner and outer ropes to enable it to be placed in position on the hangers. The scaffold ropes were fleeted, *i.e.* an additional rope was secured from the bridge brackets to the scaffold-poles outside the cable.

The standing rope was then released, the fleeted rope taking its place, and at the same time the cable was unslung from the suspending wires. The inner scaffold rope was fleeted in a similar manner, and the cable was then ready to be placed on the hangers—a comparatively simple operation.

There was nothing particularly dangerous or difficult in thus fleeting the ropes all along the length of the bridge, and after the first few had been dealt with the work became automatic to an extent, all hands realising the "wangle" and co-ordinating their actions accordingly.

The next operation was to take in sufficient cable to pass round the ornamental ironwork on the top of each pier. The hauling end of the rope was taken off the grip and carried back over the run to a point about mid-way in the last span but one, no slack being required in the last span. Here the end was tied to the cable and the winch set in motion, with the result that a "bight" was formed in the cable near the pier. The haul was continued until sufficient slack had been obtained to allow the cable to take a natural curve from the last hanger in one span, round the ironwork, to the first hanger in the next span. The hauling end of the rope was then fleeted to the next and subsequent spans and the operation repeated, the last haul taking the end of the cable off the drum.

It will be understood that the two operations, viz., (*a*) fleeting the scaffold ropes to get the cable inside, and (*b*) fleeting the hauling rope to obtain the bights in the cable, were carried on conjointly, *i.e.* last span—fleeting scaffold ropes, placing cable in hangers, fleeting hauling rope, taking bight in cable, placing bight in position on pier—then next span, fleeting scaffold ropes, and so on right across the bridge.

The photograph **A**, taken from a position adjacent to the drum at about 7 p.m., will enable those who wish to study in detail the operation outlined in these notes.

It remains only to be said that with the exception of a terrific thunder-storm at 5.30 a.m., lasting for about three-quarters-of-an-hour and during which operations had to be suspended, no hitch whatever occurred, and practically no variation from programme. The writers' thanks are due to all the men who were engaged on the work for the enthusiastic and able manner in which they tackled what was to all of them an unknown quantity.

The work was directed by whistle signals, which were responded to throughout the day in a prompt manner. The boatman who was engaged "in case of accident" was not called upon to exercise his life-saving skill, and it was a source of gratification at the end of a very strenuous day's labour to realise that "Cable across Newport Bridge, Estimate 1570," was an accomplished fact.

Particulars of the cable, etc., are subjoined—

Cable.	200/20 + 600/10 T L.C. Armoured.
Length	159 yards.
Weight—	
Cable	2 tons 16 cwt.
Drum	1 ton 1 cwt.
Total	3 tons 17 cwt.
Staff employed—	
Inspectors	2
Workmen	23
Corporation scaffolders	2
	27
Distance between cable hangers	3 feet.
Weight of cable per span, approximately	11 cwt.
Weight of cable per yard	·35 cwt.
Overall diameter of cable	$3\frac{1}{4}''$

Time occupied—4 a.m. till 10 p.m., with three $\frac{1}{2}$-hour meal reliefs.

J. H. M. WAKEFIELD.
J. RADFORD.

PERSONAL.

IT will be observed from the Staff Changes recorded on p. 316 of this issue that Mr. F. Addey, B.Sc., of the Engineer-in-Chief's Office, has been appointed an Assistant Inspector of Wireless Telegraphy in the Secretary's Office, G.P.O. Mr. Addey has been a valuable contributor to the pages of this JOURNAL, and the hearty congratulations and good wishes of the Board of Editors are extended to him on his well-merited advancement.

Messrs. R. N. Partington and R. Lawson, Assistant Engineers in the Engineering Department, have resigned from the Home Service in order to take up important appointments in the Postmaster-General's Department, Commonwealth of Australia. It is understood that these gentlemen will be stationed at Melbourne, where they will be associated with an old colleague in the person of Mr. J. M. Crawford. We beg to congratulate our colleagues on their promotion, and to wish them both success in their new sphere of action.

TELEGRAPHS

AN ECHO OF 1870.

The perusal of an "Instruction to Telegraphists and others working the Telegraphic Apparatus," dated December, 1870, provides interesting reading nowadays and incidentally proves that from the date of purchase the Department has taken the greatest care to instruct members of the staff in the efficient maintenance of its telegraph system.

As a youngster in a large telegraph office in the nineties, one was much impressed with the virility of the "old guard"; those pioneers of the seventies who in the good old days worked under difficulties at isolated points, operating single needle or sounder instruments; who, besides being telegraph operators, were test clerks and linemen too.

It is sometimes stated that there is a suspicion of over-elaboration in present-day official instructions. This charge cannot be levelled at the 1870 regulations, where direct, simple language is used, and the instructions, though somewhat crudely framed, are nevertheless definite and to the point.

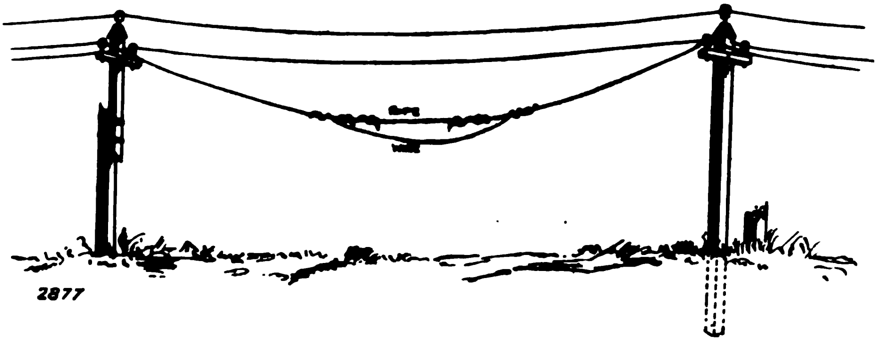
A few extracts may prove of interest to our readers:

MAINTENANCE OF APPARATUS.—"Every trained telegraphist should earnestly apply himself to master the principles and construction of every instrument that is placed under his charge. It must be remembered that under the new postal system clerks will frequently be placed in isolated positions, separated by several miles from any railway station, and where some time must necessarily elapse before the maintenance men can possibly arrive to remedy any defect that may arise in the apparatus. Telegraphists should be able to remedy such defects themselves, and a proper knowledge of the details and action of the instrument itself may prevent the occurrence of any such defects at all. No clerk will be promoted from one grade to another who is not able to pass an examination in the method of connecting up instruments in various ways in circuit.

"In no branch of business is cleanliness more essential than in telegraphy. Dirt produces more breakdowns in telegraphic apparatus than any other cause. Hence the greatest care must be taken to prevent any dust from accumulating within the keys of the sending part of the different apparatus, whether needle, bell, or printing.

"But care is also requisite in cleaning, because a stray fibre of cotton or silk, by falling on the contact-point of a spring, has frequently broken down a circuit for hours. This is very likely to occur to the bridge or line-spring of the sending apparatus of the single needle and bell instruments.

"The inside of the apparatus should always be carefully kept clean; the metal at the points of contact and at the bearings is frequently worn off by usage and accumulates as metallic dust, which, unless removed, produces contacts in the interior of the instrument.



Reproduction of an Old Sketch illustrating Temporary Pole and Wire Repairs, 1870.

"Oil is almost essential to the good working of instruments, but it must be very pure, and judiciously applied. Bad oil frequently coagulates, and with metallic dust produces a very troublesome dirt that renders the signals uncertain. It is better, as a rule, to leave oiling to the maintenance men, but every clerk should know how to apply oil when the necessity for doing so arises. This is generally shown by the instrument *squeaking* at some point."

The isolation of the poor telegraphist and the squeaking of his instrument sound somewhat pathetic nowadays.

The sections dealing with the maintenance of external plant are of special interest, and no apologies need be offered for the reproduction of the sketch indicating methods of pole and wire repairs.

"When it is found that the fault is not in the instrument, or in the office, the wires running from the post office to the railway, or main line of poles, should be closely examined. Every telegraphist should do his best to repair temporarily any damage that may arise to the wires at or near his station, bearing in mind that the wires must be kept from touching each other, and from resting on metal, wet stone, or wet wood. Rubbish, waste, kite strings should be carefully removed from the wires, and they should never be allowed to touch the branches of living trees.

"Should the wire be broken every effort should be made to bring the ends together, and join them by a piece of wire, so as to maintain a metallic circuit. The wire itself is drawn up so tight that it cannot be jointed, but it may be connected together by a wire, rope, or any contrivance, so long as the metallic connection is maintained by a piece of wire of any kind. The attached sketch illustrates a method by which this can be done. At every telegraph office should be kept a piece of spare wire for such a purpose, and every telegraphist should learn from the lineman the method of making temporary joints.

"If a pole be broken the broken post may either be tied to the stump that remains, or itself be buried in the ground, to form a shorter post, both of which methods are shown in the sketch."

The Board of Editors is indebted to Mr. T. H. Newlands, of the Telegraph Section, Engineer-in-Chief's Office, for the loan of this old record.

DUAL SUPPLIES FOR ELECTRIC LIFTS.

By P. DUNSHEATH, B.A., B.Sc.

ELECTRIC lifts in post office buildings take their energy from two distinct double-pole services—one for the motor and one for the control circuit—provided in the motor room for the contractor by the Engineering Department. In the case of push-button operation without a regular attendant, trouble is sometimes experienced owing to the burning out of operating coils through the control current being left on for long periods; but by taking care in arranging the disposition of the fuses this can be prevented in a very simple manner.

In 1 is shown the plain, straightforward method of "teeing-off" the two services. With this arrangement, should the cut-out on the motor circuit have become fused for any reason, it is possible for a person to press a button to operate the lift, and, finding it does not work, to go away again, leaving the control current (which is normally cut off again by the limit switches at the end of the travel or by the stop-push button) flowing through the winding of one of the direction switch solenoids on the control panel and in time burning it out.

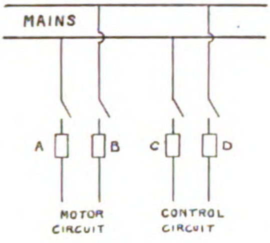


Fig. 1

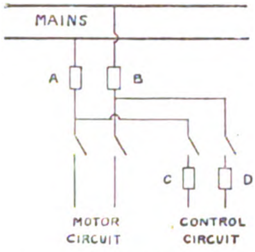


Fig. 2.

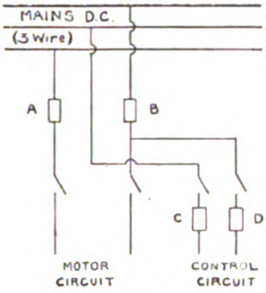


Fig. 3.

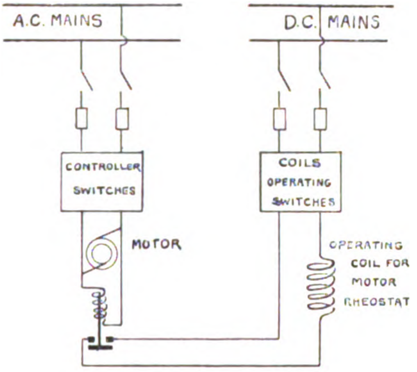


Fig. 4

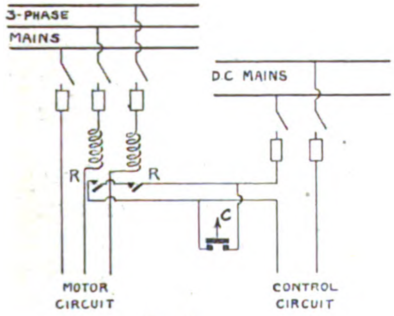


Fig. 5.

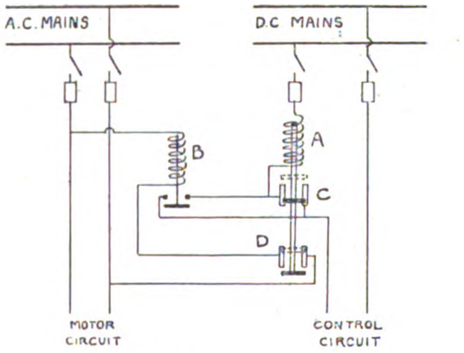


Fig. 6

2875

1.—Simple Method of "Teeing Off."

2.—Modified System for Two-Wire Circuits.

3.—Modified System for Three-Wire Circuits.

4, 5, 6.—Three Different Methods of Interlocking Two Supplies.

2 shows the modified arrangement in which the motor cut-outs "*A*" and "*B*" carry both the motor and control current. The supply for the controller is teed off the motor side of these cut-outs so that should they be blown by a jammed or overloaded cage the supply of current to the control circuit would also be broken, and no damage could result to solenoids, etc., by prolonged heating currents. It should be noticed that in order to be able to work the controller for purposes of adjustment with the motor disconnected, the D.P. switches must be inserted on the motor side of the cut-outs, and insulated fuse-carriers must be employed for safety in renewing.

When a three-wire system is available for lift work, it is usual to connect the motor across the "outers" and the control circuit between the neutral and one outer. 3 shows the correct method of obtaining the two services in a case of this kind. Here again, it should be noticed, the motor cut-outs are not covered by switches and should be of the insulated type. *C* and *D* in both 2 and 3 may consist of a simple fuse-wire across brass terminals, as they can be rendered "dead" for re-fusing by means of the D.P. switches.

In the three-wire system there is a possibility of only the fuse *A* (3) blowing, and *B* remaining intact; if this happened the arrangement would provide no protection against dangerous continuation of the control current, but if the same gauge of fuse-wire is used in *A* and *B*, the small additional control current traversing *B* will ensure its being the first to blow.

In certain circumstances two distinct supply systems are used for the motor and control circuits of a lift, as, for instance, when cheap energy can be obtained for the motor from A.C. mains, and direct current with its advantages for solenoid operation is also available for the control circuits. In cases of this kind it is necessary to interlock the supplies so that the controller cannot be operated by the control current and the motor starter thus put into the running position while the A.C. supply for the motor is temporarily interrupted.

This interlocking of supplies can be effected in several ways, different arrangements being adopted to ensure that no current is taken by the device when the lift is not in use. 4 shows a simple arrangement for single-phase A.C. motor supply and D.C. control current. In this case the simple starting control circuit is always complete, but it is only when current is available and switched on to the motor that the motor rheostat can cut out resistance and so speed up.

A simple arrangement for interlocking 3-phase and D.C. supplies is illustrated in 5. The coils of two small relays *RR* are inserted in two of the three phases, and the local contacts are normally open. In parallel with these is a contact *C*, which is normally closed but is lifted by the motor rheostat when the latter rises for speeding up. The controller can thus be operated by current passing through *C* independently of *RR*; but if the rheostat rises as the sequence of starting operations continues, at a time when the A.C. supply has failed, the current is broken and the controller falls back into the "off" position.

6 illustrates an ingenious arrangement, devised by Mr. H. W. Fulcher, of the Engineering Department, for interlocking two supplies by means of relays. The control current passes from the main through the coil of relay *A*, and, either its own contacts *C*, or the local contacts of relay *B*. The switch *C* is so arranged that when the current traverses the coil *A* the short circuiting piece rises above the contacts and breaks the current; but just before this occurs the switch *D* closes and completes the circuit of relay *B* on the motor mains, thus providing through the local contact of *B* a retaining contact for relay *A*. Should the A.C. supply fail, switch *B* will remain open even after *D* has closed, and *C* on rising will break the control circuit restoring the controller to the normal position.

EXAMINATION HUMOURS.

By And. Fraser.

(*Continued from p.* 210.)

Various methods exist for the measurement of the resistance of an "Earth," but the following runs Pomeroy's rather hard: "If possible get line cut at distant end, then measure its resistance on Wheatstone Bridge and where possible compare it with another disconnected line to same station. A mileage calculation would then prove the quality of the earth in use."

That this candidate knows what he is talking about, when it is a question of "qualities" of the earth, will be readily admitted when it is mentioned that he explains the existence of earth currents as "due to electrical disturbances in the earth such as volcanic eruptions or earthquake shocks."

Ohm's law, as a rule, is fairly well handled by the majority of candidates, but occasionally there comes along one who rejects the old well-worn track and gives us something fresh: "Ohm's law is the fundamental law underlying *all* electrical measurements; viz., that the electro-motive force in a circuit will produce a current directly proportional to the amount of resistance." [There are great possibilities here!] Closely allied with this is the following airy definition of specific resistance: "Note, the specific resistance of a conductor is its resistance to the passage of a current as compared with *air*."

The units of capacity, potential and quantity appear to be susceptible of more than one definition. To take the case of "capacity," we are told in one instance that "'microfarad' is that used for condensers when a charge is sent through a condenser and charged up, and the discharge takes place *through the opposite plate*." Not content to pause here, our technical friend mercilessly proceeds to sum up: "'Coulomb,' the timing of a current through a circuit. 'Volt,' the strength of a current through a circuit; and 'microfarad,' the charging and discharging of a condenser, which are used on cables and long circuits to increase the speed of working."

But to read, for the first time, the following definitions of the same units makes one wonder if one is standing on one's head or not: "The coulomb is the standard of capacity equal to a column of mercury 00016 centigrade high. The volt is the standard of E.M.F. given off by a battery. [" Given off" is excellent.] The microfarad is the standard of resistance inserted in a circuit."

It is positively refreshing to come down from the empyrean of the above and be told that "an ampère flowing for one second will *deposit* one coulomb." Here, thank goodness, we have something tangible which a bewildered mind can lay hold of and enable its ideas to readjust themselves.

A question as to how the conductor resistance of a line could be measured elicited the following: "Conductor resistance is for tracing incipient faults in a line. To show how they *conduct* themselves." And another question on the function of an induction coil in a telephone circuit brought out the information that "it is to reduce or eliminate the self-induction picked up from stray currents by the metallic loop."

The "megger" has not escaped the humorist. One enthusiast —he must have read Artemus Ward—describing the process of measuring the resistance of a line by its means, goes on: "Turn the handle, and step by step turn the rheo numbers from 1, etc., and when pointer is exactly on the *affinity* mark that will be the conductor resistance of the line." Good! We had long wondered where the "affinity" mark was!

The construction side of the subject is one that does not appeal to the telegraphist as a rule; he is more interested in the apparatus he handles daily. The following answer indicates that the student is convinced the Department does not intend to compete with the legitimate market gardener: "Underground lines are laid in iron pipes, the ends of which are plugged up with solid gutta-percha to prevent the growth of vegetables." And again, "submarine cables are covered with a brass sheath to protect them from the attacks of toreadors." Another man kills the ubiquitous worm by the internal application of creosote!

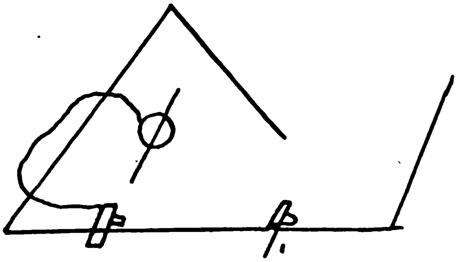
Testing has also its difficulties, but to one skilled in the use of the tangent galvanometer the localisation of a fault on a cable presents no trouble. He merely "uses the brass-ring galvanometer. It is yellow. The galvanometer is connected to a battery and to the cable. The needle will immediately commence to revolve. The greater the number of revolutions the greater the distance of the fault."

The Wheatstone bridge, both in theory and practice, is a sad trial to many candidates; and some of them, doubtless, have wished that Wheatstone had never interfered with Christie's "scientific toy" by bringing it into the domain of practical utility.

In theory the humorist *will* insert his ratios, and in practice he will keep on unplugging in the Rheostat portion, supremely indifferent to the fact that the ratio arms are plugged up. The "infinity" plug has no meaning for him. It is there, and out it must come with the rest!

Here is how one cheery optimist leads off when measuring the conductor resistance of a line: "Place the bridge to infinity and insert the proportionals. Join up the line and depress the battery key," etc.

But the possibilities of the bridge appear to be yet imperfectly understood if we are to judge from the following: "Any current of one ohm resistance or above can be measured, but under that it is not safe owing to its own internal resistance." This candidate illustrates his answer with a diagram of a type of "bridge" which is probably unfamiliar to most of our readers, and accordingly we reproduce it here.



WHEATSTONE BRIDGE.

It will surely be conceded that there are many points about it to make one think hard.

Some candidates are particularly strong in numerical work, and the easy nonchalance with which they handle vast voltages makes one tremble. Take the following case in point: the question set was to determine the E.M.F. of a battery which produced a current of 100 milliampères in a wire of 85^{ω} resistance, the internal resistance of the battery being 15^{ω}. The answer given was "100,000 volts." Tesla himself could not do more!

In the descriptions of apparatus there are occasionally to be met many original ideas, and although the reader may have difficulty in recognising, in the following description, the ordinary Standard Relay B, yet with perseverence he may do much!

"The Standard B Relay is non-magnetic and responds to currents in either direction; it requires a stronger current to overcome the antagonistic spring; to this is due the fact that the contacts are firmer when joined in series than when joined in parallel."

A polarised sounder is described as "a magnet beneath two coils on a base. The coils are capable of receiving a current in either direction and thus they neutralise the effects of self-induction and are thus adjustable to an entirely neutral position."

Again, we are told that—

"The principle of a transformer is to superimpose a circuit on to a plus."

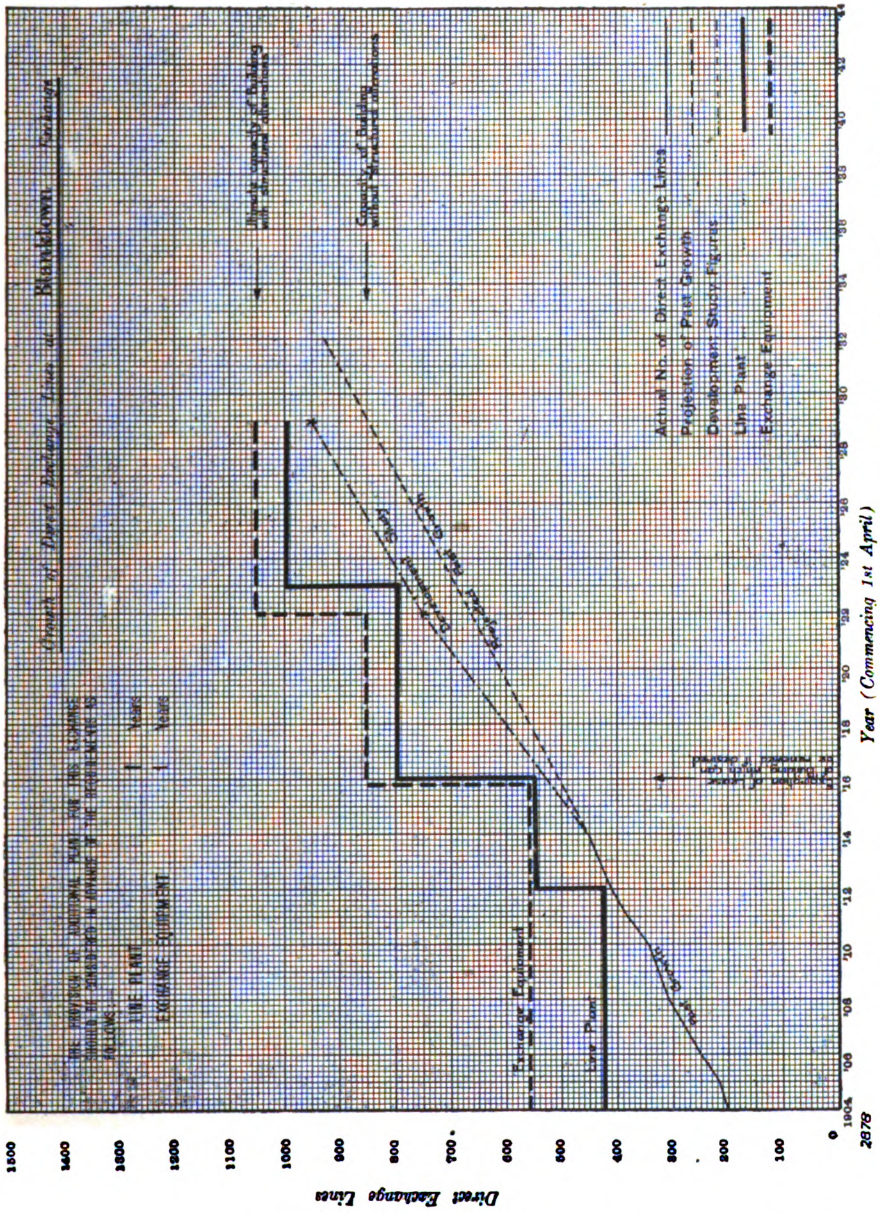
It will assuredly be interesting to Messrs. Vyle, Smart and Hay, and particularly to the first-named, to know that polarised sounders are used in C.B. working "because the magnet at the base of the sounder is placed with the North nearest the Earth to attract the Earth's magnetism."

It is a long cry from Faraday to Ewing and our modern conception of electromagnetic induction; yet when we are told that—"Electromagnetic induction is that power which a magnet may retain, in other words, the inductance of a magnet," we heartily concur, whatever it may mean; and when the statement is amplified by—"It could, it is thought, be used in subscriber's circuits," we concur more than ever. It is no use wrestling with the transcendental.

And now we bring this series of howlers to an end. They will probably have produced many smiles, but let us not forget in the midst of our merriment, that behind many of them there is also a pathos—a deep underlying pathos. And although we may have laughter in our eyes, we have a kindly sympathy in our heart for those of our less technical brethren whose shortcomings we have touched on, let us hope, with a not too ungentle hand.

A TELEPHONE EXCHANGE DANGER SIGNAL.

It is an essential factor in telephone engineering that the equipment and line plant at telephone exchanges be utilised to the best advantage and that engineers should have before them a handy record indicating when the need for additional plant arises at any particular exchange. A graphical record forms a convenient "danger signal," showing the condition of affairs at any time in



GRAPHICAL RECORD GIVING DETAILS OF DEVELOPMENT, EXCHANGE CAPACITY, AND PLANT.

regard to the exchange building, the switchboard equipment and the line plant respectively.

The accompanying graph is an example of the final appearance of a record which has been designed to meet these needs and shows:

(*a*) The effective capacity of the internal equipment.

(*b*) The effective capacity of the line plant in terms of direct exchange lines.

(*c*) The actual growth in direct exchange lines for the past ten years plotted and projected.

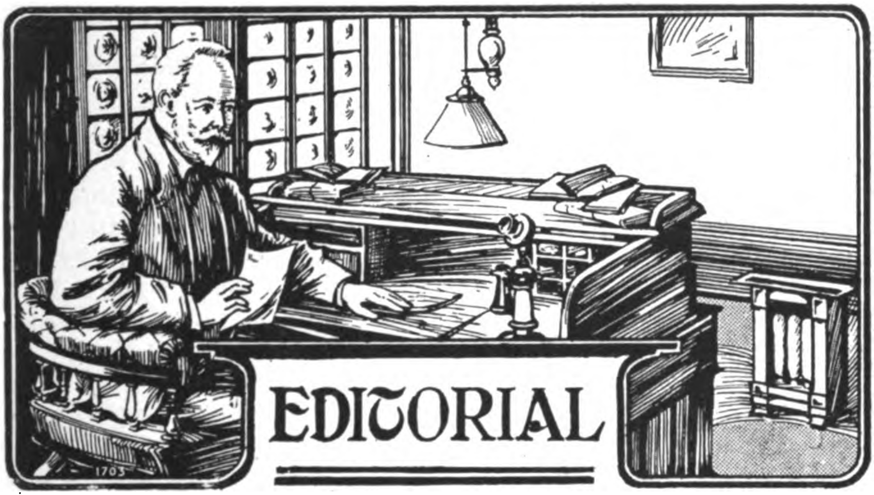
(*d*) Development figures for the eight and fifteen year periods shown by dot dash curve.

The maximum periods for which the separate items of plant are provided can be ascertained by inspection. In the examples shown the building lease expires in 1916 but is renewable, whilst the equipment can be extended, without structural alterations to the building, to a capacity of 850 lines. The ultimate capacity of the exchange, with structural alterations, is 1050 lines.

The thick, dotted line on the diagram indicates the position in regard to the exchange equipment. This will suffice until 1916; an extension at this date will provide accommodation up to 1922, but before this period is reached arrangements will be made to consider the structural alterations in order to provide switchboard capacity for the ultimate number of lines. In this connection due regard is given to operating loads, number of positions, junction equipment, answering jacks and capacity of multiple.

So far as line plant is concerned it is assumed in the example shown by the thick line in the diagram that the existing plant is in a congested state and that a relief scheme has been adopted to meet immediate needs. The cables thus provided will carry over until 1916. Before reaching this date a complete development scheme will have matured so that, before the line plant has again become congested, a full underground scheme will be in working order. The progress of line plant provision gives a clear record of the different periods for plant review, also the highest point to which the development of an exchange may be allowed to reach before such consideration is given. The period of time necessary for the operations of carrying out development study, preparation of an underground scheme, specification for exchange equipment, placing of contracts, carrying out of works, will also be recorded on the graph in the space provided, to ensure that sufficient time is given to carry out the different operations. The capacity and suitability of the exchange building should be carefully considered before expenditure on new plant is incurred.

A. O. G.



EDITORIAL NOTES AND COMMENTS.

In the present condition of international affairs some doubts may be expressed upon the wisdom of proceeding with the publication of this Journal, which exists for the object of chronicling the peaceful advance of telegraphic, telephonic, and electrical science generally throughout the services and the dissemination of this information amongst our own staff and our subscribers throughout the world. So far as we ourselves are concerned, the difficulty is not one of lack of matter due to any cessation of active operations, but rather a danger of allowing enthusiasm for the prosecution of the campaign on the Continent to make us forget the not less important necessity of carrying on business at home as usual. Even now, writing these lines in early September, we are afraid that our efforts may be futile and that the pursuit of purely scientific and technical subjects, as exemplified in our pages, will be relegated to a less exciting period when Fleet Street has ceased to issue special war editions.

Nevertheless, we consider that our obligations to subscribers and to the printing and publishing firms associated with the production of the Journal warrant the continuance of our issue; and although the present number is bereft of certain valuable articles, which we had hoped to be able to produce at this time, we trust that the pages will not be found without interest, if our readers can create for themselves an atmosphere sufficiently critical to appreciate their worth. Mr. Deane's article on "The Traffic Side of Exchange Design Work," Mr. Bell's description of the application of automatic switching appliances to manual exchanges, and Mr. Christensen's scientific inquiry into the number of selectors required to carry traffic loads are items taken at random from our contents page to indicate the important nature of the issue.

We have in hand a very valuable and important technical description of the wireless system of the Australian Commonwealth, but in view of the international position we have decided not to publish it just yet. A detailed account of recent developments in telegraph repeaters by Mr. A. C. Booth has been delayed by the calls of the military side of the State, and the publication of certain other interesting telegraph matters has been unavoidably delayed. In our last issue we gave a definite promise that the clerical Station List should be issued with this number, but we did not consider ourselves justified in pressing the at present extremely busy Staff Section to supply information which could be well held over. We hope to be able to complete Mr. S. A. Pollock's description of his cable testing methods within the limits of the current volume.

The following announcement appeared in the Post Office Circular of August 25th, 1914.

The Postmaster-General has made the following appointments:

Mr. Evelyn Murray to be Secretary to the Post Office.

Mr. H. S. Carey, C.B., and Colonel A. M. Ogilvie, C.B., to be Joint Second Secretaries to the Post Office.

Mr. E. Raven to be Assistant Secretary to the Post Office.

This brief official announcement indicates that several important changes have taken place in the Secretariat of the Post Office Service. The retirement of Sir A. F. King, K.C.B., Secretary to the Post Office, has been foreshadowed for some months and the hearty wishes of all ranks are extended to Sir Alexander on his well-earned retirement. His work at the Post Office has demanded the highest gifts of efficient administration, and, in addition to the extraordinary growth of the different departments under his care, Sir Alexander King has been closely occupied with many important questions. The magnitude of the special activities calling for urgent consideration need not be enumerated in detail here, but reference should be made to two matters of outstanding importance, namely, the transfer of the National Telephone Company's undertaking to the State, also the Committees appointed by the Government to inquire into conditions of Service of Post Office employés.

Sir A. F. King's successor, Mr. George Evelyn Pemberton Murray, is the son of Sir George Murray, and was born in 1880. He was educated at Eton and Christ Church, Oxford. From 1903 to 1912 Mr. Murray was an Examiner in the Board of Education, whilst from 1905 to 1909 he acted as Private Secretary to Lord Crewe, Mr. McKenna, and Mr. Runciman respectively. From 1909 until his appointment as Secretary to the Post Office Mr. Murray has filled the important office of Commissioner of Customs and Excise.

HEADQUARTERS NOTES.

MANUAL EXCHANGES.

Orders placed for extending existing equipment—

Brixton	1500 lines
Chiswick	1120 ,,
Finchley	900 ,,
Hammersmith	1100 ,,
Nelson	200 ,,
Streatham	600 ,,
Sydenham	1400 ,,
Walthamstow	320 ,,
Wimbledon	1200 ,,

Edinburgh (Extension for trunks and long junctions).

Paddington (Conversion of all in-coming junctions to keyless ringing).

Installation commenced at—

Cleckheaton	360 lines
Darwen	520 ,,
Lowestoft	480 ,,
Smethwick	260 ,,
Truro	300 ,,
Bristol Extension	1460 ,,
City, Manchester Extension	2140 ,,
Derby Extension	360 ,,
Sheffield Extension	600 ,,
Worthing Extension	320 ,,

Installation completed—

Victoria Extension	1600 ,,

In addition to the above several small extensions have been placed.

TELEPHONE DEVELOPMENT.

Automatic Exchanges.—A contract has been placed with the Automatic Telephone Manufacturing Company, Liverpool, for a full automatic exchange at Blackburn for 2200 lines, to operate on the multi-office area principle with an automatic telephone exchange at Accrington, now in course of construction by the same contractors.

The Hereford Automatic Exchange was brought into use on August 1st, 1914.

LONDON DISTRICT NOTES.

NEW BUILDINGS IN PROGRESS.—The erection of the new offices of the London Engineering District at Denman Street, London

Bridge, which has been held up by the strike of the London builders, has now re-commenced, and satisfactory progress is being made.

EXCHANGE EXTENSIONS.—*Hampstead.*—The extension of the multiple by 900 lines is in progress.

North.—The extension of the equipment by 1000 lines has been completed.

London Wall.—The extension of the main frame to provide 1600 additional circuits has been completed.

Central.—Apparatus has been installed to provide for the supply of standard time signals (daily or hourly) to prospective subscribers for this class of service in the City of London.

Private Branch Exchanges.—At Selfridge's the provision of three additional positions, making nine in all, has been completed.

Two-position P.B.X.'s have been provided for Messrs. Bradley's, of Westbourne Grove, and also for the Custom House.

The removal of the manual portion of the official automatic switch from G. P. O. West to the Central at G. P. O. South has been completed, and has considerably improved the traffic conditions.

NEW TELEPHONE LINES.—During the thirteen weeks ended July 28th, 1914, 5121 Exchange lines, 3398 Internal extensions, and 248 External extensions were fitted. In the same period 3788 Exchange lines, 2297 Internal extensions, and 186 External extensions were recovered, making a net increase of 1333 Exchange lines, 1101 Internal extensions, and 62 External extensions.

LONDON TRUNK EXCHANGE.—Between August 1st and August 20th 62 new trunk circuits were connected up and brought into use in the Trunk Exchange. This acceleration was due to heavy pressure of trunk traffic on the declaration of war. Normally new trunks are added at the rate of about thirty per annum.

INTERNATIONAL CRISIS.—In connection with the international crisis and the outbreak of hostilities, a large number of circuits, some hundreds in fact, were provided for various naval, military, and civil departments by the London Engineering staff at short notice. Holidays were given up, and officers and men worked Sunday duties, night duties, and excessive hours, willingly and cheerfully.

It is pleasant to be able to state that both initiative, efficiency, and ability were displayed by those called upon to deal with this work, and that appreciation expressed by the requisitioning departments was conveyed to the staff by the Superintending Engineer. The strain on the staff caused by this special work was not lessened by the facts that over 700 men were called away by the mobilisation and the energies of a large number were absorbed in connection with the closing down of all private wireless telegraphy stations. Some 700 installations were dealt with in the London district.

STAFF.—One hundred and fifty workmen, hitherto unestablished, have been added to the establishment under the Holt revision.

EXTERNAL CONSTRUCTION.—The extent to which the space underneath London roadways and footways has been appropriated for the various public services was recently brought into special prominence when it was desired to lay a line of twenty-four hexagonal ducts eastward from Park Exchange for serving subscribers in the Notting Hill and Bayswater area.

At a point five miles west of the Bank the broad Bayswater Road thoroughfare was found to have been entirely taken up by huge water mains and gas mains, together with the smaller fry of the Hydraulic Company, Electric Light Companies, and telegraphs and telephones. A parallel route from the Park Exchange to Queen's Road, Bayswater, *viâ* Pembridge Square and Moscow Road, was chosen, but, although this is a residential district, obstructions were met with in Moscow Road of such magnitude as to necessitate excavation to a depth of 18 ft.

REMOVING UNDERGROUND PLANT *EN BLOC*.—The London, Brighton, and South Coast Railway, in connection with their electrification scheme, are raising many of the bridges to give an additional 9 in. clearance above the metals. At their bridge in Bedford Hill, Streatham, the Department has four pipes crossing, one containing a heavy main cable. The Company decided to raise the bridge-deck bodily at midnight on Saturday, July 25th. It was thought inadvisable to cut the cable, and after calculating chances it was resolved to carry out the raising of the pipes in daylight, so that any mishap could be attended to under best conditions. There were no means of slinging the pipes *except* to the moon or a convenient star, so, as they were gradually lifted by our men, a 3 in. block was placed beneath each pipe and resting on the deck of the bridge, followed by a second and third to get the 9 in. elevation. At midnight, when the raising of the deck commenced, men were stationed to remove the blocks. As the deck came up 1½ in., the top block was taken out and the pipes adjusted to the under one, and so on until the last had been removed. The operation was entirely successful, and the cable shows no evidence of damage anywhere.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The Committee have been engaged in the preparation of the programme, which is now completed.

The first meeting will be held at the Institution of Electrical Engineers at 6 p.m. on October 19th, when Mr. L. B. Turner will read his paper on "Wireless Call Devices." This paper, it will be remembered, was unavoidably held over from last Session.

On account of the engagements of the Institution of Electrical Engineers our meetings will be held on the third Monday of each month, October to April (inclusive), and not on the second Monday as hitherto. In view of the war the Committee do not propose to arrange visits until National and Industrial affairs are in a more settled condition.

NORTH MIDLAND CENTRE.

A meeting of the North Midland Centre was held on July 27th, 1914, and was honoured by the presence of the Engineer-in-Chief, who made a special journey for the purpose of being present. A paper was read by Mr. A. T. Walker, who chose as his subject "Wires on Railways," and considerable helpful discussion arose out of much interesting and instructive information collected in the paper. The Engineer-in-Chief in the course of the discussion explained the recent agreements arrived at with regard to railway crossings.

Advantage was taken of the occasion to make a presentation to Mr. H. King, Executive Engineer, who retired on June 30th last, after forty-five years service spent entirely in the Engineering branch. Eloquent testimony to the high esteem in which Mr. King is held was forthcoming from all grades represented at the meeting.

SCOTLAND WEST CENTRE.

At the fourth meeting of the Session a paper was read by Mr. J. Cameron on "Workmen's Classes."

The lecturer dealt very fully with the arrangement of classes, and suggested that technical arithmetic should be taken the first year and instrument and wiring practice the second year, instead of the reverse order as at present.

It was also suggested that the Department should grant a special technical allowance to those men—up to and including the class of skilled workmen, Class I—who produce 1st class certificates in Technical Electricity, Telegraphy and Telephony. This would be a direct incentive and would generate an enthusiasm amongst the men, and would yield a better return to the Department than that from the Telegraphist, who has comparatively little opportunity of applying his technical knowledge.

The general feeling among the men themselves is that the benefits to be derived from the classes is somewhat mythical.

It was suggested that an increment of one shilling per week for each of the three subjects should be granted, and that the certificate issued by the School Board should be accepted.

Some discretionary powers should also be given in regard to the payment of railway fares for men located at places over ten miles from the class centres, and the distance should be increased when suitable local classes are not available.

Correspondence classes should be started for men away from headquarters, and supervising officers when visiting these places should give any assistance necessary.

LIBRARY NOTES.

THE following books have been added to the Central Library, and are available for issue to members :

No.
496. 'Calculation of Alternating Current Problems.' Louis Cohen.
497. 'Practical Telephony.' J. Bell and S. Wilson.
498. 'Insulation and Design of Electrical Windings.' A. P. M. Fleming and R. Johnson.
499. 'Elementary Practical Mathematics.' J. Perry.
521. 'Power-House Design.' J. F. C. Snell.
522. 'Toll Telephone Practice.' J. B. Theiss and Guy A. Joy.
523. 'Calculations in Telegraphy and Telephony.' H. P. Few.
524. 'Electrical Circuit Theory and Calculations.' W. P. Maycock.
525. 'Wireless Telegraphy.' W. H. Marchant.
526. 'Wave Meter in Wireless Telegraphy.' J. O. Mauborgne.
527. 'Depreciation and Wasting Assets.' P. D. Leake.
528. 'Slide Rule.' C. N. Pickworth.

Offers are invited for surplus copies of Poole's 'Telephony' and K. B. Miller's Telephony.'

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From.	To.	Date.
Lawson, R.	Prob. Sub-Engr.	Asst. Engr.	9 : 7 : 14
Gleed, S. W.	,,	,,	9 : 7 : 14
Frost, P. B.	,,	,,	10 : 7 : 14
DeWardt, R. J.	,,	,,	10 : 7 : 14
McGregor, J. E. M.	,,	,,	10 : 7 : 14
Marr, H. R.	,,	,,	10 : 7 : 14
Jacquest, A. H.	,,	,,	10 : 7 : 14
Jones, L. J.	,,	,,	10 : 7 : 14
McKichan, J. J.	,,	,,	10 : 7 : 14
Banks, A. E.	,,	,,	10 : 7 : 14
Mairs, J. B.	Chief Inspector	,,	17 : 7 : 14
Partridge, T. T.	Asst. Engr.	Exec. Engr.	Dates to be fixed later.
Osborn, W. M.	Engr., 2nd Class	Asst. Engr.	
Grocott, J. R.	Chief Inspector	,,	
Field, A. W.	Engr., 2nd Class	,,	
Day, W.	,,	,,	

STAFF CHANGES.

TRANSFERS.

Name.	Rank.	Transferred from.	To.	Date.
Loftus, R. W. . .	Chief Inspctr.	Testing Branch (Birmingham)	London	11 : 6 : 14
Barralet, F. O. . .	"	London	E. in C.O.	14 : 6 : 14
McCabe, W. J. . .	3rd Cl. Clerk	North Eastern	Ireland	1 : 7 : 14
Walsh, R. . . .	"	"	North Western	13 : 7 : 14
Betts, G. . . .	"	North Western	North Eastern	13 : 7 : 14
Banks, A. E. . .	Asst. Engr.	London	South Lancs	11 : 7 : 14
Bishop, G. . . .	3rd Cl. Clerk	North Western	South Eastern	17 : 8 : 14
Coates, G. A. . .	Asst. Engr.	North Eastern	"	1 : 8 : 14
Jacquest, A. H. . .	"	South Midland	E. in C.O.	4 : 8 : 14
Addey, F.* . . .	"	E. in C.O.	—	4 : 8 : 14

* Appointed Assistant Inspector of Wireless Telegraphy, Secretary's Office.

RETIREMENTS.

Name.	Rank.	District.	Date.
King, H.	Exec. Engr.	N. Midland	1 : 7 : 14
Lawson, R. (resigned) .	Asst. Engr.	E. in C.O.	10 : 8 : 14
Jones, E. A. . . .	2nd Cl. Clerk	South Wales	10 : 7 : 14
Partington, R. N. (resigned)	Asst. Engr.	South Eastern	31 : 7 : 14

DEATH.

Name.	Rank.	District.	Date.
Corless, W. H. . . .	Chief Inspector	South Lancs.	22 : 8 : 14

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COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.

A few copies of Part 1, Vol. 1, of the JOURNAL are required by the Board. Full price will be paid for copies in good condition, or another part can be sent in exchange. The JOURNALS may be sent to the Managing Editor direct, or through the local agents.

Binding covers and copies of the Contents Index for Vol. 6 are now available, and may be obtained from the local agents for 1*s.* and 2*d.* respectively. Subscribers can have their copies bound, with index included, at a cost of 1*s.* 9*d.*, by sending the JOURNALS to the local agents. Orders should indicate whether the original binding covers, or the later pattern, are required.

A supply of the first instalment of the Station List of Engineering Officers eligible for membership of the Institution, issued with the April number of the JOURNAL and including all officers down to Assistant Engineers, is in stock, and copies can be obtained on demand, price 3*d.* each.

THE NEW YORK
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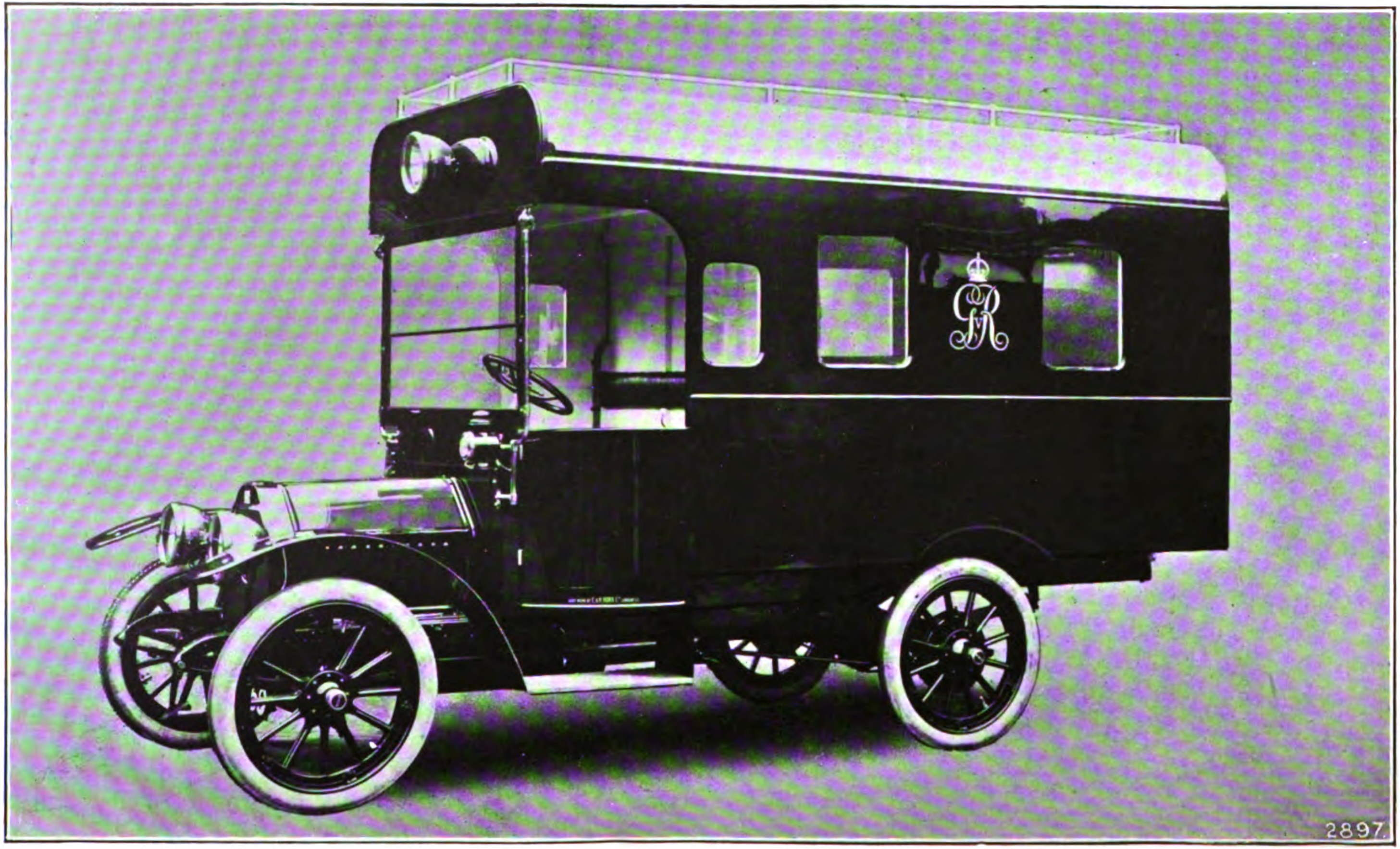


New Post Office Van equipped with Apparatus for Testing Underground Telephone Cables.
(See Mr. Pollock's Article in this Issue.)

THE
Post Office Electrical Engineers' Journal

TELEGRAPH REPEATERS.

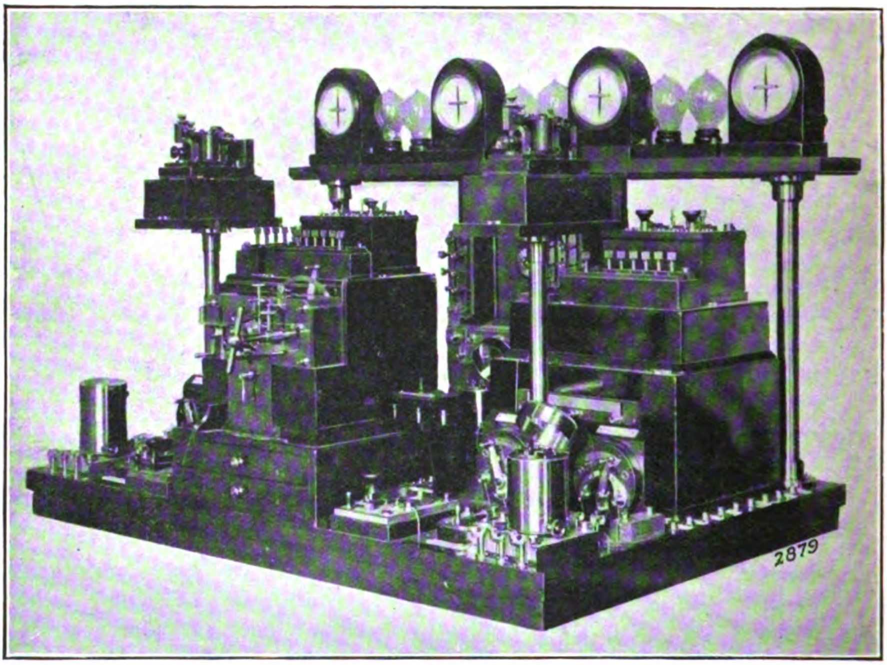
By A. C. Booth.

The Post Office type of repeater being the model generally followed by Colonial and other telegraph administrations, manufacturers of telegraph apparatus are always anxious to obtain details of any changes in post office design. The following information regarding some recent modifications may be of particular interest not only to our own readers, most of whom have little or no opportunity of getting in touch with the development of these complex sets of telegraph apparatus, but also to our colonial readers, who specify in their forms of tender to the various manufacturers that the latest post office design must be followed. The recent changes or developments have arisen to meet requirements mainly in connection with the introduction of Baudot Duplex on the Anglo-German cable circuits, and the extended application of high-speed apparatus to the long underground cable circuits between the important centres.

A view of the repeater used for Baudot Duplex working on the Anglo-German cable circuits which pass through the North Walsham Repeater Station, illustrated in Vol. 6, Part 4, of this Journal is shown at 1.

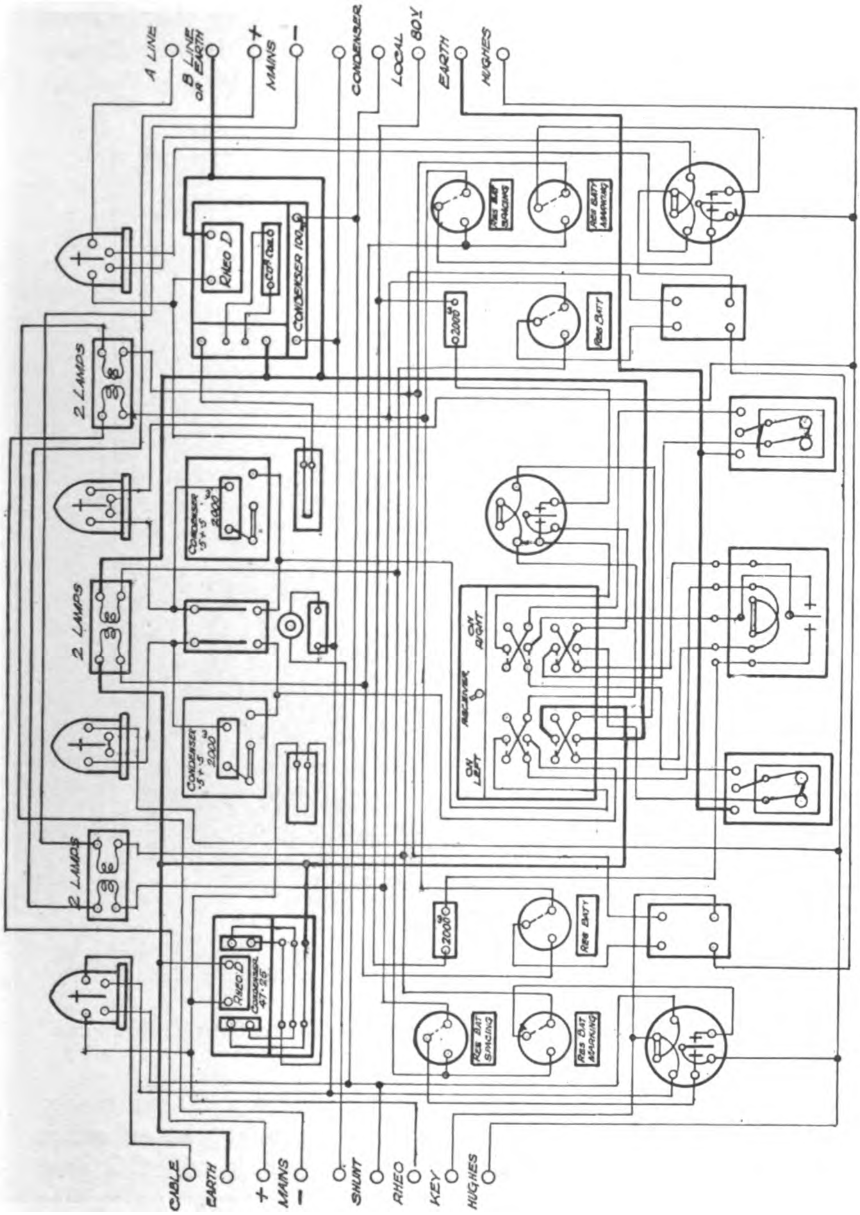
It will be observed that there are two galvanometers for the Leak circuits, so that outgoing signals are always under observation without the need for turning a switch. As the Baudot is not worked at simplex on these circuits, it has been possible to simplify considerably the connections and the amount of apparatus used. There are no neutral relays, no automatic switches, and no 8-bar switch. The board is, however, used at night-time for Simplex Hughes working, necessitating provision for single-current working, which is arranged by turning a switch to cut off the spacing voltage and to replace it by a resistance. The cable section itself is kept always at duplex, and the aerial section is put out of balance sufficiently to avoid return signals to cable.

For balancing purposes, "resistance" is given by turning the 2-way switch connected to the signalling key. This arrangement does not disturb the battery connected to the line relay on the other side, with the result that communication is maintained on one side whilst the other side is balancing. This is not the case with the older form of Wheatstone repeater. Should it be desired to balance through the contacts of the "line" relay, then the other two 2-way switches can be used, giving the equivalent of the 6-terminal 2-position switch on Wheatstone repeaters. The switches are also used if it be desired to clean the relay contacts. This, however, should not be done on this form of board, as provision has been made for replacing the relay by another in a matter of about two seconds. This provision will be described later on.



I.—Repeater, Differential Duplex, for Baudot Duplex.

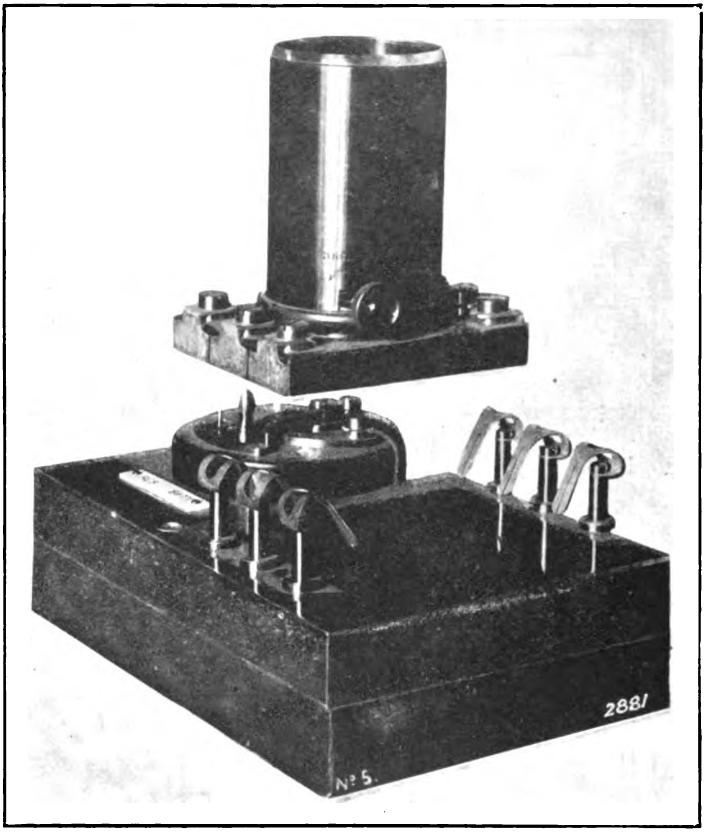
The old peg switch for changing the Wheatstone receiver from one leak to the other has been replaced by a throw-over switch known as " Switch, Repeater, Leak, 24-point," illustrated in detail in



2.—Connections of Repeater, Differential Duplex, for Baudot Duplex.

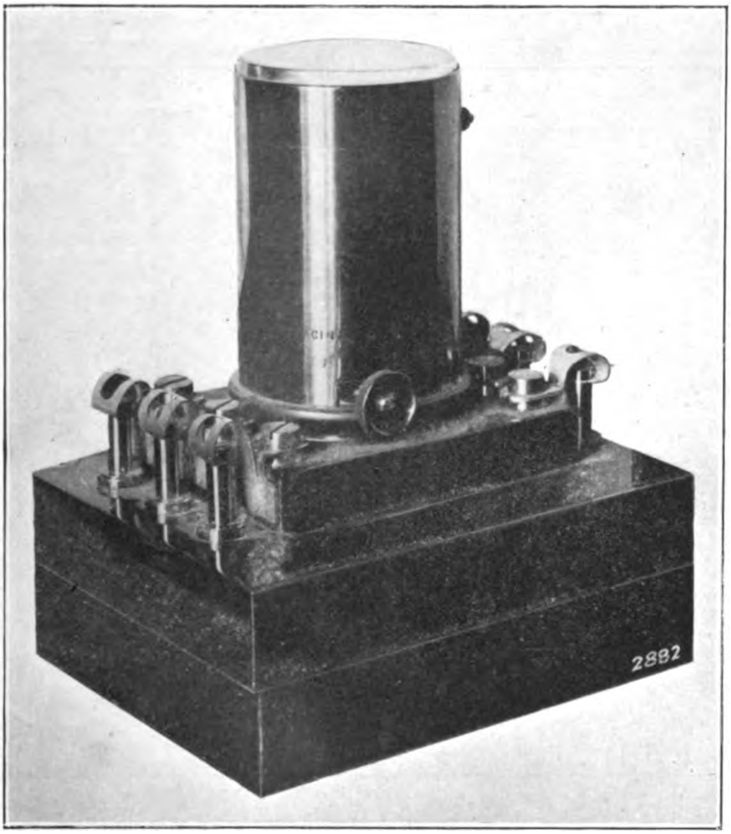
Vol. 6, Part 1, which is the equivalent of an 8-bar switch in a small space. It is made up in the form of a telephone switchboard speaking key. By its means the Wheatstone receiver is changed almost instantly from one leak to the other; the position of the handle indicates by its direction the side of the repeater to which the receiver is connected.

The additional contacts of this switch are used to change over the sounders, in order to retain the sounder on the right-hand side for the station which is working on that side. There is thus no possibility of mistaking from which direction the signals are arriving. In the older form of repeater the "Up" station might be on either sounder according to the position of the peg switch. In this case the "Up" station is always on the right-hand sounder, no matter which side the Wheatstone receiver may be. Incidentally, there is a middle position for the switch handle, and in this position the sounders are actually reversed. This forms a ready means of testing, but is not a recognised working position.



3.—Standard Relay with Rectangular Base, showing Contact Springs.

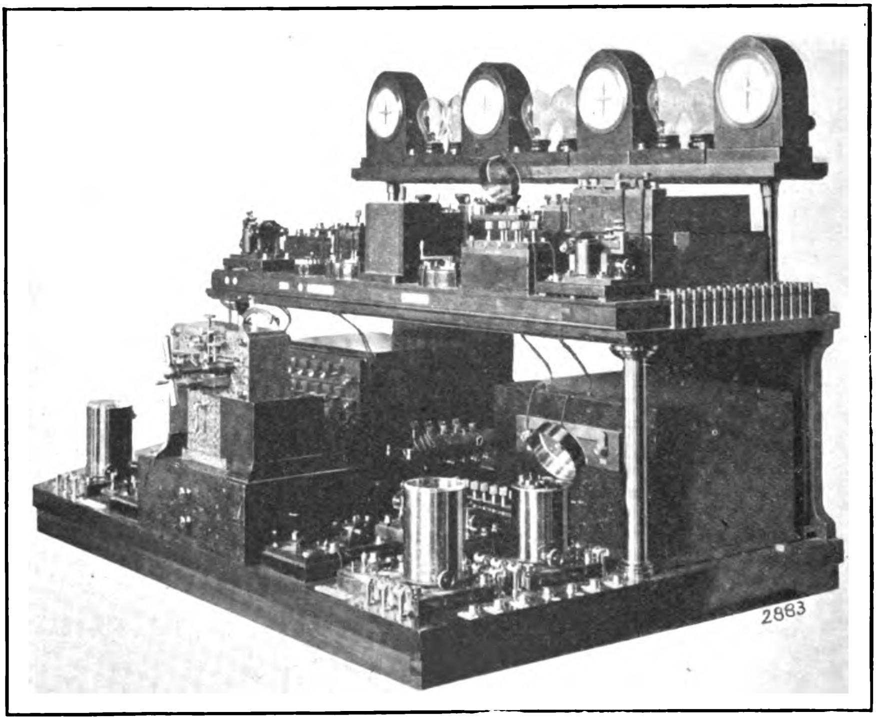
The connections (2) on both sides are arranged for differential duplex, as it is found that this method is more favourable than bridge duplex under the particular difficulties that have to be met on the 4-conductor cables in question. The relay on the cable side has a condenser of 100 mf. and an inductive shunt of low resistance (1 henry and 37 ohms) joined across the outer terminals.



4.—Standard Relay with Rectangular Base, in Position.

Another feature of this repeater is the ease with which the relays can be changed. The relays, which are the usual Post Office Standard Relays, Type B, wound to a resistance of $100^{\omega} + 100^{\omega}$, are fitted on rectangular wooden bases (3) instead of on the usual circular type. This alteration was made to enable spring contacts to be used to equalise the pressure at both front and back. The change has proved economical in space on repeater boards. Each terminal is fitted with a brass contact piece, which when the relay is in position (4) makes a very firm electrical contact with a phosphor bronze spring clamped to the usual type of pillar terminal. To change a relay, all that is necessary is to lift it out of position and to press another into its place, an operation which occupies about two seconds.

Spare relays, already cleaned and adjusted, are kept at hand for the immediate replacement of any working relay that may show signs of sparking or sluggishness in action, and there is therefore no necessity to stop a circuit to clean a relay, or to go through the time-wasting process of undoing fourteen screws and then screwing them up again, as on the older Wheatstone repeaters.

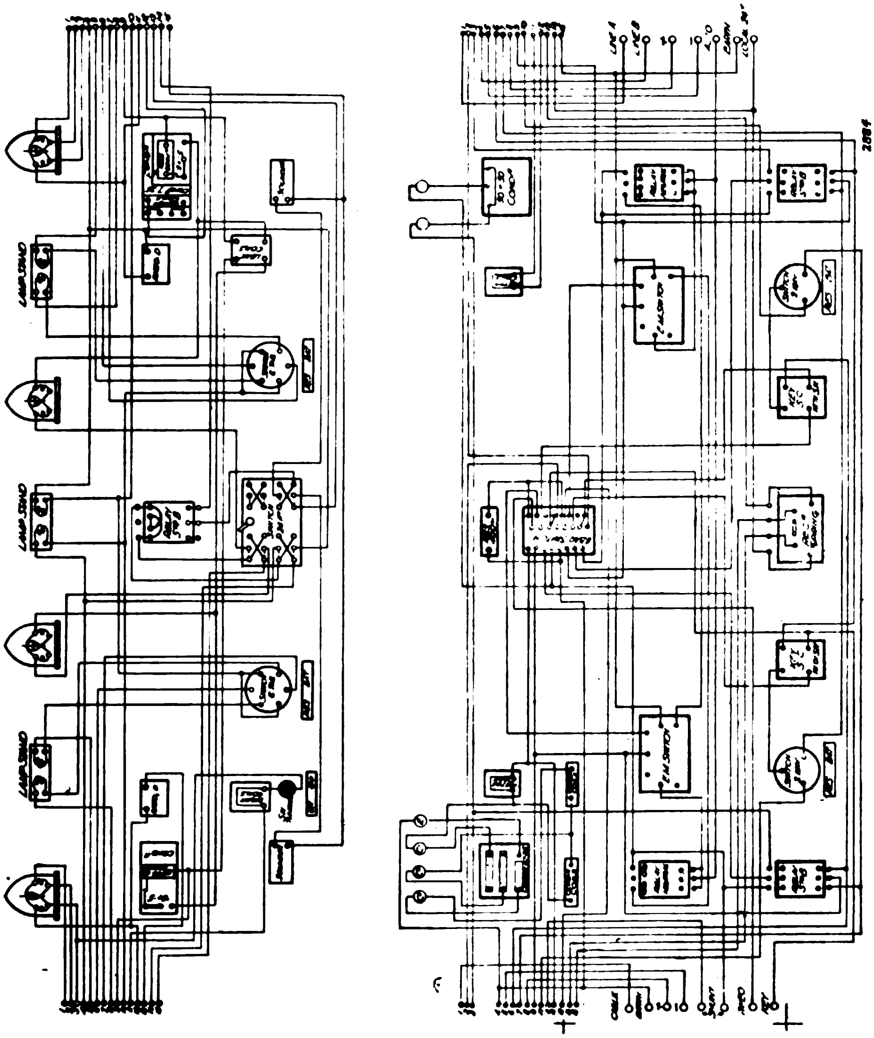


5.—Repeater for Indo-European Lines.

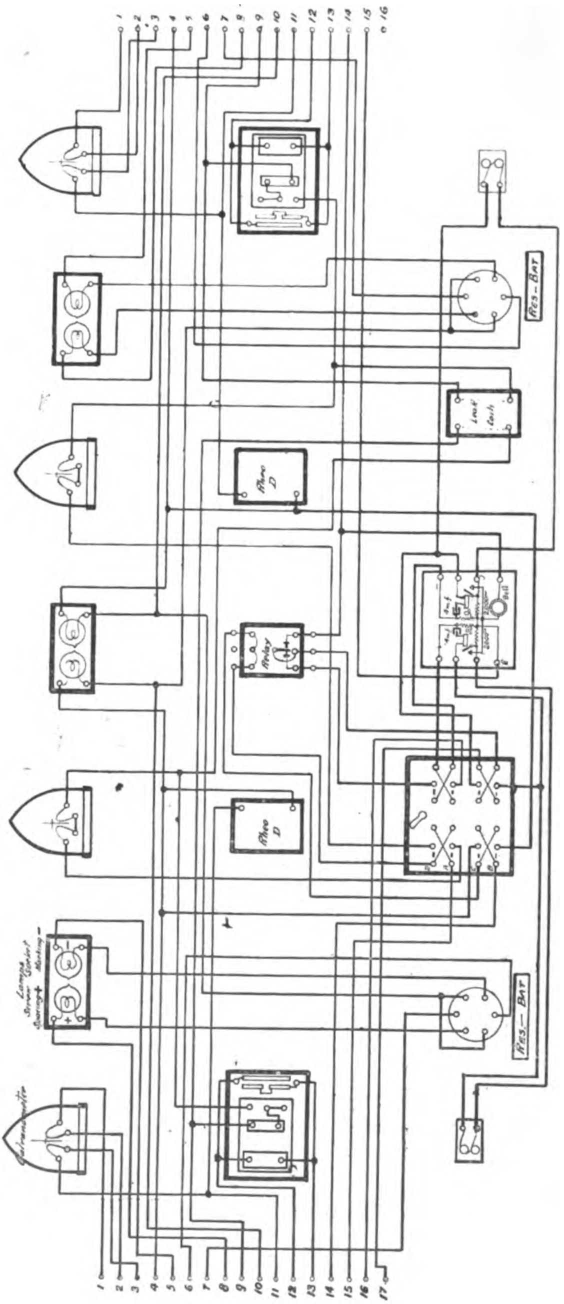
At the request of the Indo-European Telegraph Company the Post Office have undertaken to equip and maintain the repeaters in this country which work on their long lines to India, and for this purpose the repeater shown in 5 has been designed.

It is an elaborated Wheatstone repeater arranged for simplex or duplex as required, by the turning of the usual 8-bar switch. Both sides have been arranged for differential duplex working, and the improvements enumerated in regard to the repeater for the Baudot Duplex working have been embodied.

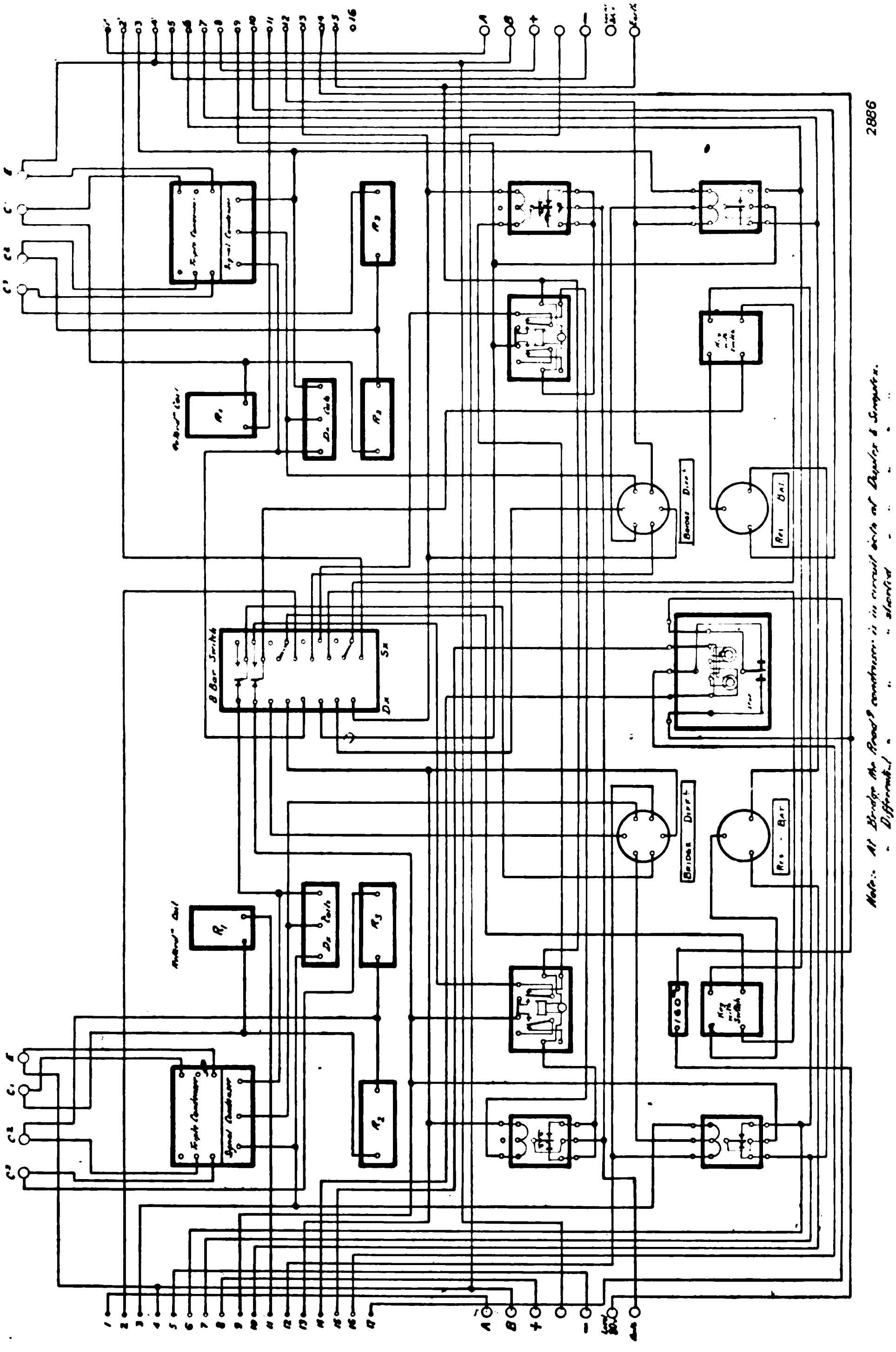
A further departure has been made from the older Wheatstone repeaters; at simplex the sounder on the right hand is always worked by London, and one on the left is always worked by the eastern station. This arrangement entails that the leak circuits are always on, but as the leak current is only 4 milliampères the disadvantage is outweighed by the advantages gained, viz. a permanent indication of the main batteries on either side at simplex, and the retention of each sounder to its proper side.



6.—Connections of Repeater for Indo-European Lines. The Top Figure shows Wiring of Upper Deck, the Bottom Figure the Lower Deck. The Pillars shown in 5 connect the Corresponding Leads.



7.—Bridge and Differential Repeater. Connections of Upper Deck, joined to Corresponding Terminals on Lower Deck by Pillars shown in 9.



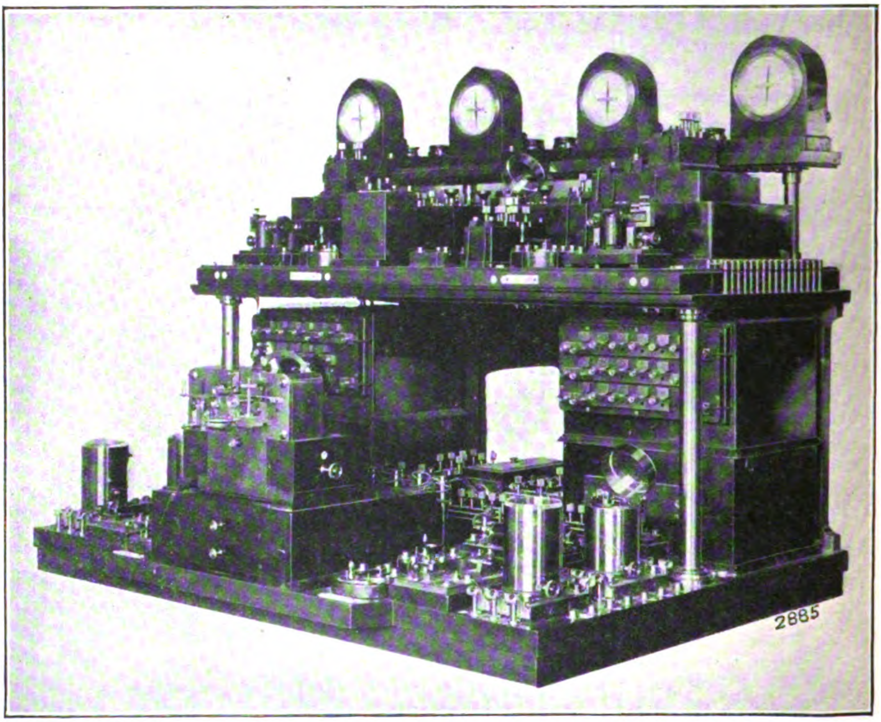
Note:- At Bridge the Road condensers is in circuit only at Duplex & Simplex.
" Differential " " " shorted " " " "

8.—CONNECTIONS OF BRIDGE AND DIFFERENTIAL REPEATER. LOWER DECK.

The full connections of this repeater are shown in **6.**

It will, no doubt, have been observed that there is no provision for a sounder silencer in either of these repeaters. The reason for this is that continuous attention is demanded in both cases.

The long underground circuits working with high speed apparatus have to be fitted with repeaters when the lines exceed about 200 miles in length. In some cases the required speed is obtained with differential connections on both sides, but in others, when the repeater cannot be installed at or near the electrical centre, it may be necessary to fit differential duplex on the shorter side and bridge duplex on the longer side; in certain instances both sides have to be arranged for bridge simplex-duplex working.



9.—BRIDGE AND DIFFERENTIAL REPEATER FOR UNDERGROUND LINES. (THE SILENCER SHOWN IN **7** IS NOT IN POSITION.)

To meet these demands a repeater, **7** to **9**, has been designed to provide either differential or bridge duplex connections on either side independently by merely turning a throw-over switch. The improvements already mentioned in regard to the other two repeaters have been embodied as far as possible. In this case, however, a sounder silencer has been fitted that is a departure from the earlier form, which used a condenser to actuate the sounder and to bring in the local battery. The reason for the departure is due to the fact that the adjustment of the sounder could not be altered to any extent without incurring the risk of throwing the silencer out of action. With the arrangement shown, the condenser discharge actuates a drop-indicator, which rings a bell. This arrangement allows the attendant to adjust the sounder to suit his particular fancy without in any way jeopardising the correct working of the silencer.

MORE ABOUT QUADRUPLEX.

WE have received the following communication from Mr. J. M. Fernandez Lamothe, C.A. Railway Telegraphs, Rosario, Argentine, which will no doubt be of considerable interest to all telegraph men. In order to make his argument clearer, we reproduce the skeleton diagram of the American quadruplex system that accompanied Mr. Bell's article in our April issue (**1**).

"In an article entitled 'Some Notes on American Telegraphs,' which appeared in the POST OFFICE ELECTRICAL ENGINEERS' JOURNAL of April, 1914, by Mr. John Hume Bell, the statement is made that the American arrangement of the *B* or No. 2 side of quadruplex 'appears to offer an advantage over the British method, as it obviates the need for two relays in the case of repeaters, and also in that it permits uniformity in the wiring of both *A* and *B* local circuits.'

"The main advantage, however, that is, its greater efficiency, seems to be overlooked, and in fact few telegraphists realise the reason for this superiority, or at least I have never seen this matter fully explained.

"The American system not only has the advantages mentioned in the above article, but the arrangement in itself is more effective in correcting the breaking of signals and permits quadruplex working on longer lines, other conditions being equal.

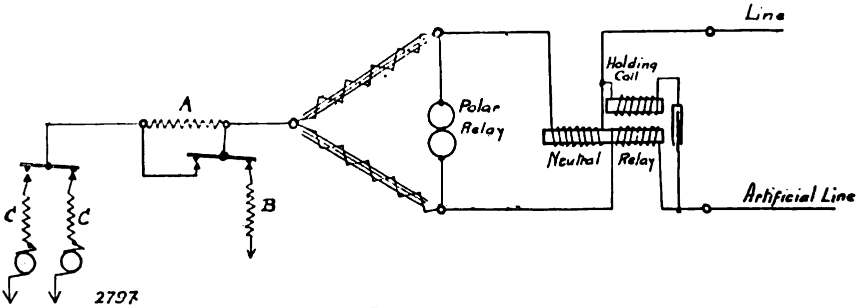
"Let us examine both methods and see why it is so.

"In the British system (**2**) the *B* relay is allowed to break when the current is reversed at the distant end, but the gap is bridged in the sounder by the discharge of the condenser *C*, which holds the sounder armature down during the period of no magnetism. But the condenser discharge takes place not only when a signal is split in the relay through the operation of the distant *A* key, but also and just the same at the end of every dot or dash made by the distant *B* key, and therefore tends to fill the spaces between them.

"On such a principle the theoretical limit of working is reached when the length of the break (period of no magnetism in the neutral or *B* relay) is as long as the spaces between the successive elements of a letter, as it would be impossible to fill the breaks without at the same time joining these elements together, forming a continuous dash. The practical limit, however, is reached much sooner, as the margin between the filling of the breaks and the keeping of the signals clear becomes so reduced that the working is rendered precarious and practically impossible long before, as is easily understood when considering that an increase in distance (or *KR*) readily causes the break-lengths to be increased while the spaces are reduced, thus leaving no margin for correction.

"It is seen that the object is not exactly obtained. The arrangement to be perfect should be one that will correct the breaking of the *B* signals caused by the *A* reversals, without in any way affecting the *B* signals themselves.

"This purpose is more closely obtained by the American holding electro-magnet and condenser system, as shown in 3. Here the discharge of the condenser *C* through the coil *H* holds the armature against the working stop while the line magnets are momentarily demagnetised during reversal of the current, when the condenser discharge is most effective, and is practically inactive between *B* signals.



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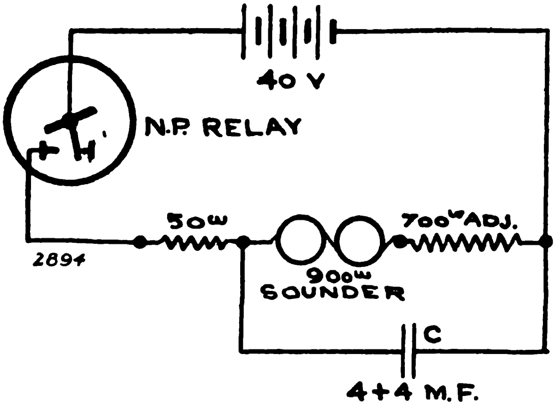
"It is in this particular effect where the high efficiency of this system lies. Assuming a ratio of 1 to 3, when the *B* key is down the condenser charge is + 3, and in reversing the potential changes to − 3, hence the difference of potential, and consequently the discharge and effect for bridging the breaks, is equivalent to 6.

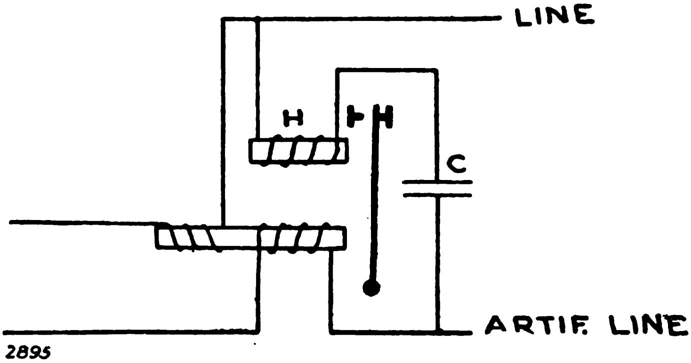
"Now, the charge when *B* key is up is 1, when it is down is 3, hence the discharge, or the effect tending to join the signals, is only 2.

"The working margin is widened, and the signals in many cases are so perfect that an operator may ignore whether he is receiving on a *B* or on a *A* side.

"All that has been previously said refers to the receiving arrangements, but there is still another reason, relating to the sending part of the instruments, which further increases its efficiency. It has already been shown that the widest margin is obtained when the reversal breaks are short, and the spaces between dots and dashes are larger, because it makes it possible to fill the gaps and still keep the signals clear. The advantage of the American system, in this respect, lies on the use of the transmitter, against the key employed in the British system, as the former gives sharper signals with greater spacing than the latter.



2.—*B* Side Local Circuit.



3.

"By thus improving both the receiving and sending arrangements the American quadruplex has reached a remarkably high degree of perfection."

THE TRAFFIC SIDE OF EXCHANGE DESIGN WORK.

By H. F. E. Deane, A.M.I.E.E.

(Continued from p. 261.)

JUNCTION AND DESK EQUIPMENTS.

THE prediction of the future junction equipment required at an exchange is probably the most interesting problem associated with this department of traffic work. Many factors must be considered, and it is not an easy matter to lay down definite rules applicable to all cases.

The projection of the development and of the busy hour outgoing junction calling rate curves in accordance with the general principles already laid down, enable us to predict the total originating outgoing junction busy hour traffic.

Before we consider the relation between a bulk of outgoing junction traffic and the number of junctions which will be required to carry it, it is proposed to explain a direct method of ascertaining future junction requirements. This method has its limitations, but may be employed with advantage in some cases.

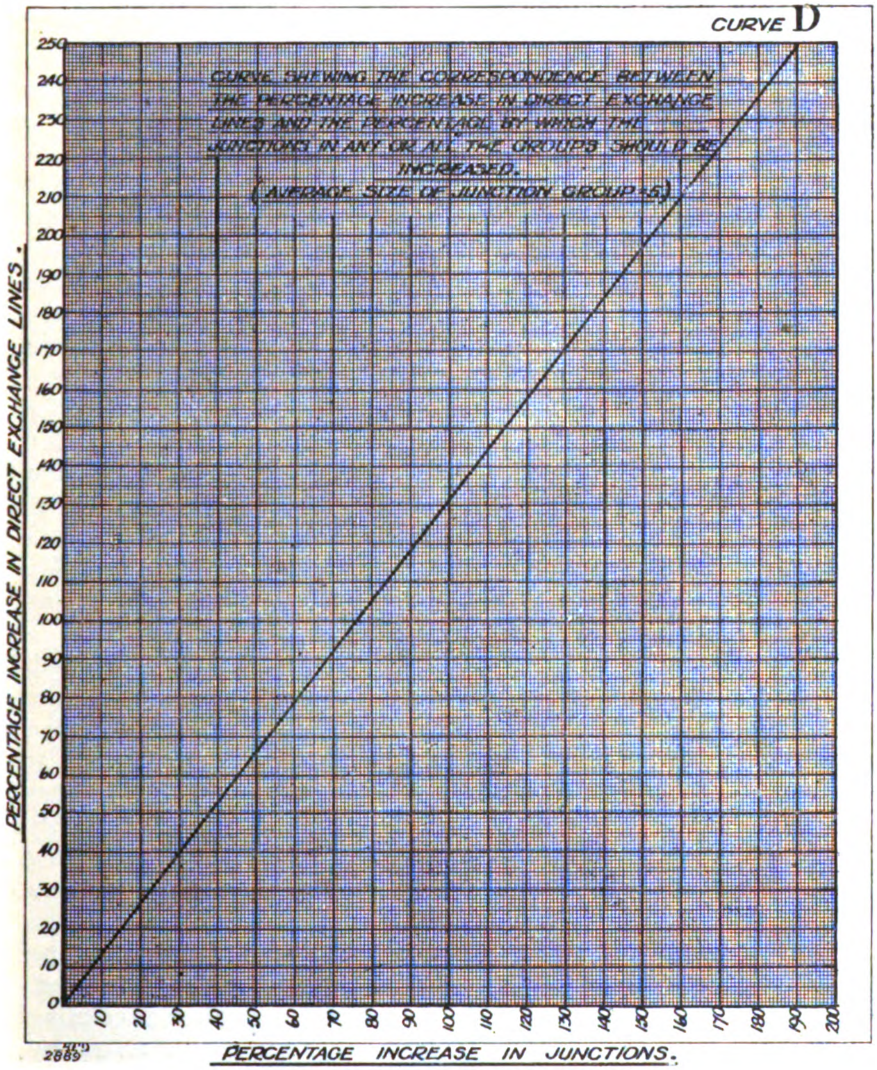
We will assume that the average size of the junction groups at the exchange under consideration is about five and is not likely to exceed nine. If we examine the formula upon which the junction provision curves are based, or the curves themselves, we shall find that a group of five junctions will be increased by 76 per cent. if we increase the junction traffic by 100 per cent.—whatever the holding time.

If we adopt this as a general basis for exchanges of fair size, we obtain a rough method of estimating the number of junctions required at future dates. Curve D has been prepared in order to obtain direct readings. For different local conditions, other curves could, of course, be prepared. The advantage of this method is that it is applicable to one group of junctions, or to the junctions as a whole, irrespective of the size (within the limits specified) or number of the groups, or the holding time—even if this varies on different groups.

If the outgoing junction calling rate is estimated to change, we first ascertain the percentage increase in the outgoing junction traffic, and then refer to the curve.

EXAMPLE.—The direct exchange lines at an exchange are estimated to increase from 300 to 450, and the outgoing junction calling rate from ·85 to ·93 in five years' time. The junctions existing and on order number seventy. How many junctions will be required in five years' time?

The outgoing junction traffic will increase from 255 to 419 or by 64 per cent. The corresponding increase in junctions is 48·8 per



cent. (see curve). The estimated number of junctions will therefore be 104.

The disadvantages of the above system are: (*a*) certain limits have to be assumed with regard to size of junction groups; *b*) the principle does not admit of the addition of new groups. The curve should, therefore, only be applied to exchanges which are likely to have few additional groups; (*c*) the junctions existing and on order are presumed to be correct for the existing junction traffic. If this is not the case, the error is projected.

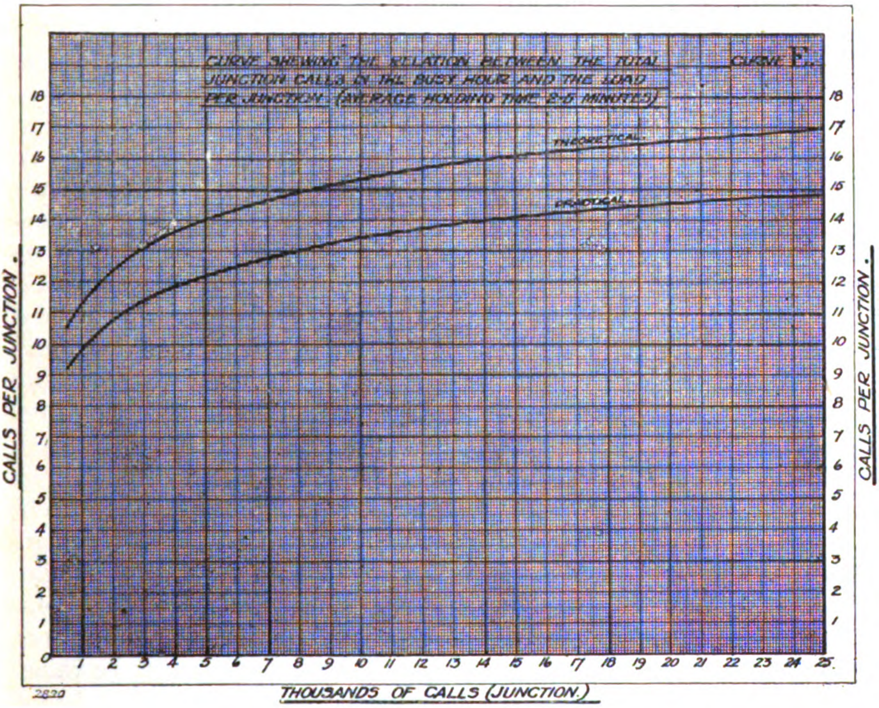
This rough method may be applied, of course, to incoming junctions as well.

It is generally admitted, in connection with this subject, that it is necessary, on most points, to appeal to practice. For example, it would be difficult to predict, without reference to the conditions which exist, that when an exchange has so many junction calls in the busy hour, so many groups of junctions will exist. As a matter of fact, the number of junction groups existing at an exchange may be regarded as something concerning which there will be the least possible discrepancy between theory and practice. In the writer's opinion the same argument applies, but not with equal force, to the size of the various junction groups or to the average size of the groups. If junction groups have, in the past, been increased in accordance with well-established rules, there is no reason to apprehend that the junctions existing at an exchange are not required for the traffic. In this connection the case of London may be regarded as somewhat exceptional—the chief reasons being the large amount of transfer work constantly taking place, which, in spite of general precautions, has a disturbing effect on the junction traffic, and a natural reluctance to part with junction circuits which may probably be required in the near future in consequence of the rapid line development in the case of many exchanges.

With regard to holding time, we must again, it is considered, appeal to conditions as we find them. Although no very definite relation exists between the amount of junction traffic and holding time, it may be taken as a general rule that the holding time at large exchanges is less than that at small exchanges. The nature of the conversations and the amount of ineffective work are probably the principal factors which must be taken into account. Holding time not only varies between exchange and exchange, but varies in the course of time at all exchanges. The gradual decrease in the proportion of ineffective calls and the less rigid restrictions respecting length of conversation are bringing about a higher holding time. If present conditions are going to be a guide to us when predicting future junction requirements, it appears very necessary to revise any figures we may use periodically in order that this question of holding time may not be neglected.

If we therefore plot a curve showing the relation between the busy hour junction traffic at all the exchanges in an area, and the corresponding junctions required in practice (existing and on order), we appeal on all points—including an allowance for junctions which may be out of order—to existing practical conditions.

The present London practice differs from the method above described inasmuch as it is not always known, as already stated, whether the junction provision is correct for any particular exchange. Some explanation will be required concerning curve *E* which is used. If the busy hour traffic which should be carried by each individual junction group at an exchange be added together and the sum compared with the total busy hour junction traffic obtained from the peg-counts in accordance with the principles already explained, it will be found that the totals differ, and that the figure obtained from the peg-counts is less than the other. The reasons for this are: (*a*) The busy hour for each junction group is not coincident. (*b*) Junctions are placed on order at times which are busier than those for which switchboard positions are provided. (*c*) A 4 per cent. allowance is made for junctions which may be out of order.



The upper curve has been plotted after ascertaining what traffic each group should carry at each exchange in the Metropolitan area if the holding time were 2·5 minutes. The incoming groups at each exchange were examined, and the total traffic which all the groups should carry on the assumption that the busy hour was coincident was calculated. The holding time was considered constant in order to obtain a common basis. The calls per junction which the curve shows for varying amounts of busy hour junction traffic are higher than could be attained in practice, not only because the junctions are ordered on busy records and the busy hour for all groups is not coincident, but also because no allowance has been made, at this stage, for the additional junctions added to the groups to replace those which may be out of order.

The lower curve, used for working purposes, takes these points into consideration. It has been ascertained from general investigations which have been made that the upper curve is approximately 10 per cent. higher than could be worked to in practice, because junctions in individual groups are placed on order at busy times. The upper curve is also 4 per cent. higher than the truth because of the allowance made for junctions which may be out of order. Altogether, then, it is 14 per cent. higher than it should be for practical work. The lower curve, the value of which is 87·7 per cent. of the upper curve, has therefore been plotted and represents the calls per junction per busy hour which we may expect for varying amounts of busy hour junction traffic. It is used in connection with both outgoing and incoming junction studies after a separate investigation has been made respecting the average holding time at any exchange under consideration. This question of holding time has, for the time being, been purposely treated as a separate matter, and inquiries are in progress concerning the possibility of predicting this important factor on scientific lines.

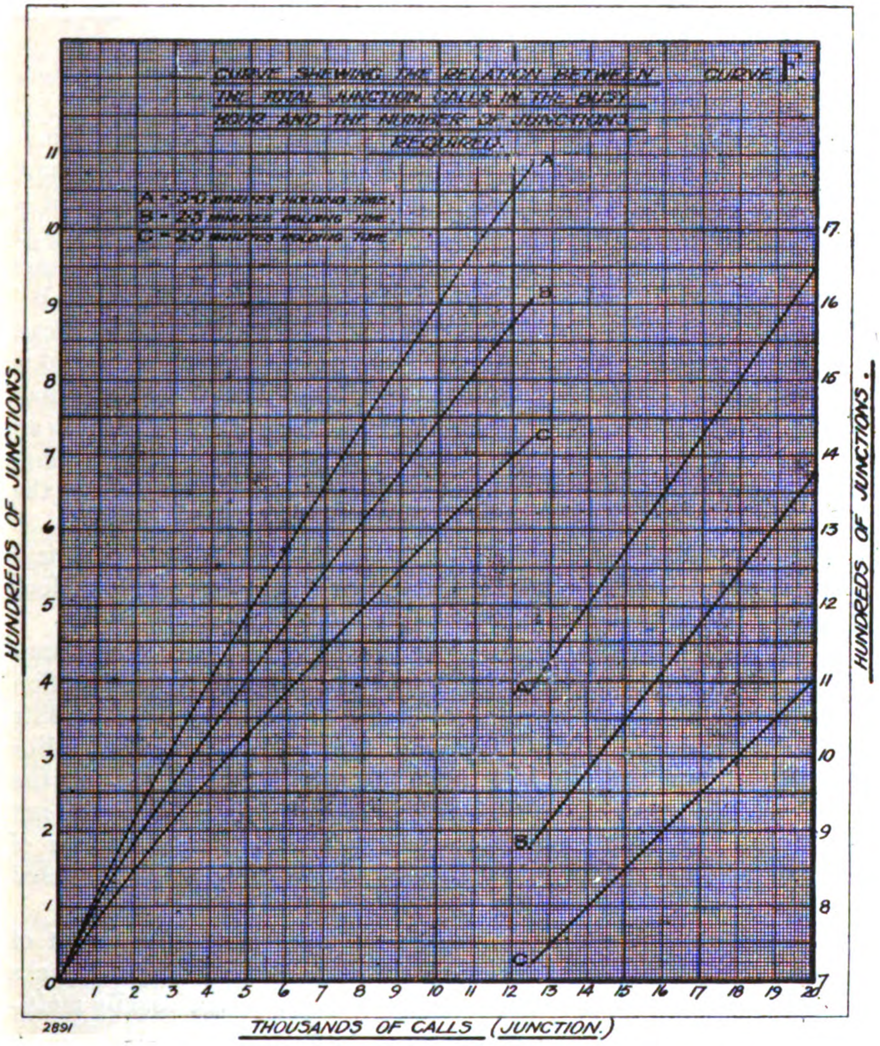
In addition to this important question of holding time, it is probable that the investigation of the near future will concern itself with the two following problems: (*a*) Whether the percentage difference between the two curves we have been discussing should be constant all along the line; (*b*) whether there is any close connection between the number of calls per junction per busy hour and the equating factors applicable to junction traffic (*i. e.* average value of the junction call in terms of the unit call).

In the writer's opinion, it would be preferable if the curve we have been discussing did not take into consideration transfer work in partial multiple exchanges. An easy separate calculation can always be made with regard to local traffic treated in this manner. Further, if we are dealing with junction centres we must make a separate allowance for portions of junction groups used for borrowing and lending purposes.

Curve *F* enables us to obtain direct readings of the junctions required for different amounts of junction traffic. It is derived from curve *E*, and it will be seen that curves are plotted for varying holding times.

Closely associated with outgoing junction equipment is the provision of service lines.

The Traffic side must determine which service lines should be known by code, and should consequently appear in the outgoing junction multiple. On the general assumption that the existing service lines are correct in number, any future increase is determined, as a rule, on a ratio basis. In other words, the ratio between the total busy hour originating and incoming traffic and the number of service lines is kept constant for any particular exchange. The number of outgoing junction jacks required for the estimated outgoing junctions and service lines follows a simple rule which has been found in practice to work well. In order to avoid unnecessary distribution of junction groups when junction circuits are added, it is



found that twenty jacks should be supplied for every seventeen junctions, etc. This excess provision of outgoing junction equipment proves cheaper in the long run if the cost of effecting alterations in the relative position of the junction groups is taken into account. Such alterations, in addition, tend to destroy the alphabetical grouping of junctions, which is of such service to the operating staff.

We shall now briefly discuss a few miscellaneous questions associated with outgoing junction equipment.

The frequency of the outgoing junction multiple in the panels appears, at first sight, to depend upon the percentage of outgoing junction working. In London, where this percentage is high, it is desirable that no effort shall be necessary on an operator's part to cover the whole of the outgoing junction field. A six-panel multiple satisfies these conditions both on the "A" and the "B" side in a standard exchange. Although it might appear economical, if the percentage of outgoing junction working were low, to employ an outgoing junction multiple which recurred less frequently than once in six panels, it must be remembered that there is a limit to an operator's vision—even with the best outgoing junction marking. It will be clear that this argument cannot be equally applied to the subscribers' multiple, which is comparatively simple to read.

In C.B. 10, C.B. 12, multiple C.B.S., and 100 line Magneto boards, the outgoing junction multiple should recur once in four panels.

The outgoing junction equipment over the "B" positions accommodates the service lines only, unless the exchange is a junction centre. These service lines may or may not be the same, according to circumstances, as those appearing over the "A" positions. For example, "complaint" lines are usually not multipled over the "B" positions, and lines to the testing operator are usually not multipled over the "A" positions. Any increase in the number of service lines appearing over the "B" positions is usually calculated on a ratio basis.

Where "A" and "B" boards are adjacent, the arrangement of service lines is not so flexible, because the particular strips of jacks accommodating the service lines on the "A" side are usually multipled on the "B" side.

The complete "A" outgoing junction multiple must be fitted over jack-ended "B" positions accommodated on the "A" side or adjacent to "A" positions in local exchanges, for obvious reasons. Also, as testing operators require the use of the outgoing junctions or testing and other purposes, the complete outgoing junction multiple must be within easy reach of the testing positions.

If an exchange is a junction centre, we must accommodate in addition to the service lines, the following circuits on the outgoing junction multiple over the " B " board:

(1) Junction groups intended for lending purposes only.

(2) Ringing junction groups appearing on the " A " outgoing junction multiple.

(3) Particular order wire groups appearing on the " A " outgoing junction multiple if tandem working is in operation.

Designation strips are required in cases (1) and (2) and most probably in case (3).

In order to deal satisfactorily with the arrangement of outgoing junctions on the " A " side and to form an estimate of the outgoing junction capacity on the " B " side in the case of junction centres, it is necessary to take into consideration both the probable number of groups which will exist and their size.

Attention has already been drawn to the fact that for a given bulk of outgoing junction traffic we may appeal to practice, with very little liability to error, if we wish to determine the probable number of junction groups at some future date. A curve showing the relation between these two quantities is used for this purpose.

We then proceed as follows:

(*a*) The difference between the number of existing groups and those estimated by means of this curve will naturally represent the additional existing exchanges which will be brought into direct junction communication with the exchange under consideration.

(*b*) To these additional groups we must add those which may be established with exchanges serving new exchange areas likely to be created during the period under review.

(*c*) An estimate, based on local knowledge, must then be made of the various size of the new exchange groups (*a*) and (*b*).

(*d*) The total estimated junctions in these new groups must then be subtracted from the total additional junctions estimated for the exchange in accordance with the method already described.

(*e*) It now remains to distribute the remaining junctions among the existing groups.

(*f*) We subtract the estimated busy hour traffic on the new groups from the estimated total additional outgoing junction traffic for the exchange, and obtain the additional junction traffic to existing exchanges.

(*g*) We ascertain what percentage increase this traffic bears to the existing outgoing junction traffic.

(*h*) As a preliminary step we increase the traffic on each existing junction group by this percentage, and then ascertain what additional junctions we should add to each group. The total junctions so added should approximate to those in (*e*).

(*i*) We may modify the additions made to each group in accordance with local knowledge (*e.g.* future transfer of lines to be made, restricted development at other exchanges, etc.).

It is only after this calculation has been made that we can say definitely how many outgoing junction jacks on the "A" side should be provided with designation strips, and how many should not be so provided. We are also now in a position to form an estimate of the number of junctions to be accommodated on the "B" side at junction centres. A separate study is usually made of the ultimate number of junctions used only for lending purposes. Their increase is, as a rule, not very great on account of the establishment of direct junction communication. The probable growth of sub-exchanges should also be watched. If they become important enough to have incoming order wire working, their incoming ringing groups from the junction centre, if of fair size, are split up, one portion being worked by order wire for the use of the junction centre, and the other portion being used for lending purposes only.

The estimated number of outgoing junction groups enables us to determine the number of order wire keys which will be required. We must, however, make allowance for multiple order wire groups unless order wire selectors are in use. A knowledge of the destination of the junction groups enables us to estimate how many order wire keys should be associated with the order wire lamps. Traffic requirements are best satisfied by an alphabetical arrangement of the order wires. This implies that all the order wire keys should be capable of being connected to the order wire lamp. If this is not considered an economic arrangement, separate strips of order wire keys are required with the double contacts. It should be noted, however, that the same use cannot be made of the order wire keys if strips of two patterns are employed. Further, the separation of the order wires to exchanges to which a fee is chargeable from the others discounts to some extent (especially in the case of junior operators) the utility of the order wire lamp. Order wire keys should be in strips of ten, six, or five, according to ultimate requirements. An order wire key to the testing operator and a key associated with the instruction circuit should be included in the estimate where necessary.

The prediction of the number of incoming junctions required at an exchange at some future date is based on the same rules observed in connection with outgoing junction supply. The projection of the development and busy hour incoming junction calling rate curves in accordance with the principles described, enables us to estimate the total number of busy hour incoming junction calls. We then employ curve *F* to ascertain the number of incoming junctions required to carry this traffic. At partial multiple exchanges it is best to treat the local traffic independently. Some traffic men prefer to draw a curve showing the ratio between the outgoing and incoming junction busy hour calling rate, and to project this curve in order to ascertain the total incoming junction traffic during the busy hour at some future date. The method possesses certain advantages, especially when an estimate is required of the equipment at the ultimate period.

Some preliminary remarks are necessary before the method of ascertaining the number of " B " positions required is described.

In Appendix No. 2 we have a comparison between the busy hour loads which " B " operators, attending to various classes of " B " positions, are expected to deal with in the London Telephone Service and those adopted by the late Company. It will be noticed that the maximum average load that can be handled by a " B " operator with maximum efficiency under machine ringing conditions is represented by 500 calls in the busy hour. The two systems agree fairly well on this point.

Under both systems it is specified quite clearly that the loads laid down are well within the capacity of efficient " B " operators, and can easily be exceeded at times. The importance of this point will be noticed later. The difference (about 10 per cent.) between machine ringing and manual selective ringing loads is also approximately the same in each system. The main difference is that in the case of straight and multiple order wire groups the London system expects more from operators than the late Company did, whilst in the case of split order wire groups the reverse applies.

With regard to split order wire loads, an important point must be taken into consideration. In the first place, is the difference between such loads and that which a straight order wire operator is supposed to take accounted for by the greater practical difficulty which a " B " operator experiences in selecting junctions from different groups for allotment ? The view of the London Telephone Service is that, although a slight difference must exist, we are, as a matter of fact, making the operator's capacity for dealing with calls subservient to the existing capacity of the " B " positions. In other words, under existing conditions the capacity of a split order wire position for accommodating junctions is exhausted before the operator's capacity for dealing with calls is reached. If this contention is considered reasonable we are working at low loads on such positions. On the other hand, in the case of large order wire groups, it is common knowledge that at present the full capacity of the " B " positions cannot be utilised without overloading the " B " operators.

It should be noted, however, that, even with the existing " B " position capacity, the standard loads are very often not reached on split order wire positions. In a recent case which the writer personally dealt with, it was impossible to arrange for standard split order wire loads on certain positions, because of the transmission difficulties which would result. This was due to the large number of small order wire groups. It may be argued that if this difficulty is experienced now, it is not of much use considering higher split order wire loads and larger split order wire " B " position capacities. It is considered in such cases that the general rule of converting junctions to order wire working when there are five circuits should be revised. If investigation shows that the existing rule is generally reasonable, we must resort to the automatic call seeker.

On the whole, the writer considers that the time has arrived when the capacity of " B " positions required for different purposes should be specified in order that equipment may not be wasted on the one hand, and that a number of " B " operators may not be underloaded on the other hand. It should not be a difficult matter to estimate exactly what is required. It is admitted that, under the proposed conditions, " B " operators initially will be more isolated than at present, and that the supervision may have to be slightly increased during the early life of the exchange. It may also be argued that the flexibility will be less, but it is not considered that these are sufficient reasons for continuing the present practice.

Having come to the conclusion as to what capacity is necessary for different classes of " B " positions under machine ringing conditions, we have to increase such capacities after taking into consideration the effect of keyless ringing, the increased holding time due to decreased ineffective work, etc.

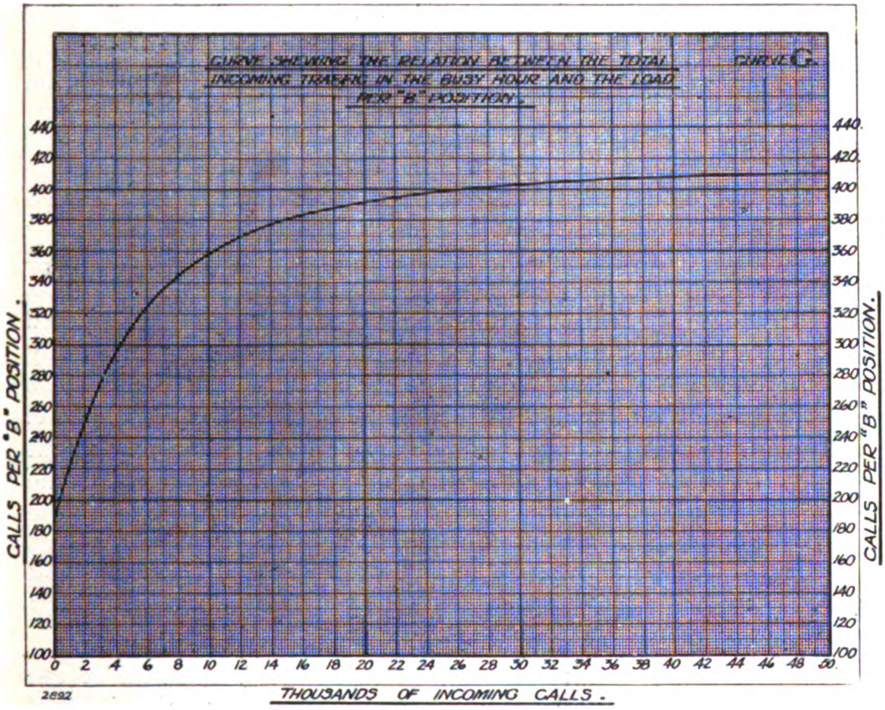
The capacity of ringing junction positions and those accommodating circuits from the Trunk exchange require special consideration.

The late Company specified that its " B " loads were only applicable to standard exchanges with six panel multiples.

To what extent the introduction of keyless ringing increases " B " operators' loads is a point which has not definitely been determined in practice. It is generally considered that an increased efficiency of 15 per cent. is too high.

The conversion of ringing junction positions from machine to keyless ringing can only be regarded, in the writer's opinion, as a means of improving the service rather than of increasing loads, and it is very doubtful if the expense is at all commensurate with the estimated improved service. Even if we are dealing with entirely new equipments, the advantage gained is doubtful. The same remarks apply generally to the conversion of ringing junction positions to jack-ended positions. The question is dependent in some measure upon what load we are forced to take on a ringing junction position due to its restricted capacity, and to what extent we hope to raise it by providing more capacity on a jack-ended position. If the load on a ringing junction position is already 190 or 200 during the busy hour, it is doubtful whether we should convert the junctions to jack-ended working on the "A" side, unless, of course, these are special reasons. These remarks do not apply to new equipments.

Having ascertained the total incoming traffic at some future date, we may appeal direct to practical experience and use a curve, such as curve *G*. This is based on the state of affairs existing in London at the present moment. It implies that when the incoming traffic at an exchange (not a partial multiple exchange nor a junction centre) assumes a certain figure, we may expect a number of "B" positions of various classes, and, therefore, a certain average load per "B" position. Naturally, as keyless ringing becomes more prevalent, etc., and if the capacity of "B" positions is increased in proportion, higher loads will prevail in course of time. Such a curve, therefore, requires periodical revision. In the writer's opinion, although a curve of this kind may be used as a guide, it is on the low side so far as the conditions which should exist in London are concerned. The same reason which prevents us adopting existing junction provision as a basis for future junction requirements should prevent us adopting



existing "B" position provision as a basis for future "B" position requirements. It will be obvious that if unnecessary junctions exist on certain "B" positions for the reasons already explained, the number of "B" positions will be greater than necessary under existing "B" position capacity conditions.

It has been argued that a "B" operator should only deal with her standard load when the traffic on the group or groups of junctions she controls reaches the figure on which the junctions were placed on order; and that we should consequently reduce the value of curve *G* by 12·3 per cent. (compare curve *E*). This, however, appears unsound when we consider the nature of "B" operators' loads and the efficiency of "B" operators. It is true that "B" operators cannot help each other, and for this reason their load is made flexible. Besides, senior operators are employed on the "B" side, and operators attending to busy order wire positions may be considered the most efficient in the exchange.

Strictly speaking, therefore, when the bulk of busy hour incoming traffic is equivalent to the figure on which the number of "B" positions was based, the standard load should be dealt with at each "B" position according to its class. The fact that, in practice, a slightly lower average load than the standard is sometimes worked to, is an acknowledgment that there are other conditions prevailing which prevent us from working to the average standard load, such as "B" positions with insufficient capacities, transmission reasons, etc.

If we were sure of the efficiency of existing conditions, we might equally well obtain the number of "B" positions required at some future date by dividing the estimated number of junctions by the average number of junctions per "B" position.

In important design studies the number of junction groups and the size of the groups should be estimated as already explained, and the number and class of "B" positions required then calculated.

If we know the destination of junctions and the size of the various groups it is not a difficult matter to specify the class of wiring (*e.g.* magneto order wire, monitor order wire, trunk exchange ringing, etc.). Lamp-flashing circuits are now no longer necessary.

If we consider the busiest class of "B" position, and the probable number of cords connected to the busy-back jacks when all the cord circuits are engaged, the existing practice of fitting five busy-back jacks per "B" position provides ample facilities. In the course of time, although the "B" position capacity may be increased, the ineffective work will decrease. In extreme cases the "B" operator is amply safe-guarded, because she can connect to the busy-back jacks on adjacent "B" positions.

The number of cord circuits required on an "A" position depends upon the following:

(*a*) The manipulative time, on the part of an average operator in setting up, supervising and taking down connections. This is naturally affected by such factors as junction facilities, education of subscribers in telephone matters, amount of private branch exchange work, etc.

(*b*) The percentage of ineffective work due to subscribers and junctions being engaged, no replies, lamp glows, etc.

(*c*) Work carried out by the operators on their initiative. This is closely associated with (*b*) above.

(*d*) The necessity for using two-cord circuits whilst establishing connections of a particular kind, such as money box calls.

(*e*) The average length of conversation.

Some careful experiments were carried out at Gerrard and London Wall Exchanges in 1910, in order to ascertain the relation between the cord circuits required and the operator's hour load in actual calls. The chief points on the curve obtained are given below:

Cord circuits in use.	Actual calls per operator per hour.
4	57
5	69
6	81
7	95
8	109
9	125
10	147
11	175
12	220

The average holding time was 2·25 minutes, and the percentage of junction working was 74.

As operators vary considerably in their efficiency, it is obvious that we cannot provide cord circuits merely on the basis of an average operator's requirements. It is therefore necessary to ascertain to what extent certain operators are more efficient than the average. The writer need not refer to the details of the records taken to ascertain this point, but he was satisfied at the time that the telephone administration should cater for operators with 33 per cent. greater efficiency than the average. Particular operators with abnormal capabilities for dealing with calls were not catered for.

Again, we must not only satisfy the requirements of efficient operators, but we must make allowance for the average load being exceeded at particular times, as, of course, it will be. A safe figure is a 10 per cent. margin. Lastly, we must consider the possibility of cord circuits being out of order. This question is naturally affected by such points as the following: Day load per position, quality of maintenance, age of the exchange, design of cords, etc.

A record taken in 1910 at a standard exchange three years old, well maintained, and provided with steel conductor cords, showed that we must expect at least one cord circuit to be out of order during the busy hour on one out of four positions. For practical purposes one additional cord circuit per position is necessary in order to meet the risk. In exchanges with one or two positions this margin is not sufficient, if we neglect the load efficiency of operators seated at such positions, which will be end positions. Now, in the case of Gerrard and London Wall Exchanges, the average number of calls dealt with by each operator when she is handling the standard load is 142. At times, each operator on the average may be dealing with 156 calls. Efficient operators will deal with 208 calls. They will consequently require twelve cord circuits, or thirteen altogether if we make allowance for one cord being out of order.

It is, of course, known that on particularly busy days very efficient operators have all their cord circuits (seventeen) in use—but these are exceptional circumstances.

Naturally, more than thirteen cord circuits would have been required with a higher holding time, and as the holding time in London is rising, this question of cord circuit supply is particularly interesting at the moment.

It should be mentioned that the number of cord circuits in use for varying hourly loads in actual calls given in the table above varies somewhat from the number required on a curve based on mathematical and general considerations.

For example, if the writer refers to such a curve, he finds that fourteen cord circuits are required for an hour load of 208 calls at a holding time of 2·25 minutes; or altogether fifteen cord circuits if allowance is made for one cord being out of order.

As an "A" operator answers calls outside her own position in 20 per cent. of the cases, the number of universal cord circuits with which she should be provided, if she is adjacent to a jack-ended junction position, is five. This is an outside figure, and it assumes that all the position cords would be in use at busy times, that all team work would be carried out on one side only, and that one of the universal cord circuits would be out of order.

It is not possible, without a considerable amount of investigation, to state the number of junction cord circuits which would be required for different classes of "B" positions. For general purposes it may be mentioned, however, that twenty-seven cords appear to be correct in number for straight order wire groups; for large multiple order wire groups it might not be necessary to fit more than twenty-one cords; thirty cords satisfy split order position conditions where two or three groups of junctions are involved; thirty-three cords are necessary on split order wire positions accommodating four groups. In some cases thirty-six cords might be required. When we consider that we have to make allowance for (*a*) the higher efficiency due to keyless ringing, (*b*) the possibility of order wire working being deferred to a later stage than at present, (*c*) increasing holding time, (*d*) the probable introduction of the automatic call seeker, it is obvious that the whole question requires careful consideration.

On jack-ended junction positions it is possible that seventeen cord circuits may be insufficient in the near future.

The type of exchange equipped to meet different conditions is as follows:

C.B.S. Two positions. 120 to 240 lines.

C.B.S. (multiple). Where more than two positions are necessary. Ultimate capacity 1000 lines (experimental at present).

C.B. 10 or C.B. 12. Ultimate capacity 2000 or 3000 lines according to whether the subscribers' multiple recurs once in four or in six panels respectively.

C.B. 1. Ultimate capacity, 10,000 lines.

At this stage it will be desirable to deal with the details of the sailing chart which the Traffic Branch should prepare, and to which allusion was made at the commencement of this article.

The factors which may vary from an estimate in course of time are (1) the development, (2) the busy hour originating calling rate, (3) the equating factor.

In the first place, it is desirable to work to a particular period when dealing with dates of switchboard equipment exhaustion. Suppose we wished to ascertain whether the capacity of each exchange would last for two years from the date the sailing chart was got out. If the sailing chart is prepared once in six months, it is only necessary to deal with projected development and traffic data during the next two and a half years. It may sometimes be necessary to look further ahead, but this is exceptional as regards extensions.

Let P represent the number of "A" positions in an exchange, e the number of end positions, and L the equated load per position per busy hour.

Then $L\ (P - {\cdot}15\,e)$ represents the total equated traffic that can be handled on the switchboard during the busy hour.

If $C =$ the originating busy hour calling rate and $E =$ the equating actor, then

$\frac{L\ (P - {\cdot}15\,e)}{C\ E}$ represents the number of lines which the exchange can accommodate.

Now if the amount of answering jack equipment or the size of the subscribers' multiple be not the controlling factor, the problem is to ascertain at what date $D \times C \times E = L\ (P - {\cdot}15\,e)$ where D

represents the development. Curve H — (derived from curve B) is used to reduced the expression $L\ (P - \cdot 15\, e)$ from equated to actual calls. The correcting factor shown by curve C is used in conjunction with this calculation. The usual practice is to plot a curve for each exchange. A horizontal line is drawn representing the capacity of the "A" positions in actual busy hour calls, and a curve representing the product of the development and busy hour calling rate during the next two and a half years is also plotted. If the curves cross, an extension study is put in hand. The date of exhaustion is naturally represented by the point where the two curves intersect.

If we do not wish to plot a curve for each exchange another method may be adopted, which is sufficiently accurate for general purposes.

Let A represent the actual busy hour calls which can be dealt with on the existing positions, ac the product of the existing direct exchange lines and busy hour calling rate, and a^1c^1 the product of the estimated direct exchange lines and busy hour calling rate in two and a half years' time. Then the equipment will be exhausted in $\frac{2 \cdot 5\ (A - ac)}{a^1c^1 - ac}$ years.

Example.—An exchange consists of ten "A" positions (two end positions), equipped with 920 answering jacks. The existing lines number 800 and the existing busy hour calling rate is 1·25. In two and a half years' time it is estimated that these figures will rise to 900 and 1·26 respectively. The percentage of junction working is not expected to rise beyond 80 per cent. during this period. Calculate the date of exhaustion of the answering equipment.

The total equated calls which can be dealt with during the busy hour on the existing positions $= L\ (P - \cdot 15e)$ or $220\ (10 - \cdot 3) = 2134$.

By curve H (see page 250) these calls are equivalent to 1036 actual calls.

By curve C these calls are increased to 1091 when the correcting factor (·95) is applied.

Date of exhaustion $\frac{2 \cdot 5\ (1091 - 1000)}{1134 - 1000} = 1 \cdot 7$ years or 1 year 8 months hence.

It should be noted in the above example that fifty-two answering jacks cannot be used.

In those cases where the existing answering equipment (and not the positions) is the controlling factor the formula is simpler. It becomes $\frac{2 \cdot 5\ (J - a)}{a^1 - a}$ where $J =$ existing answering jack equipment.

If the subscribers' multiple is the controlling factor (*i. e.*, where it is not 5 per cent. in excess of the answering equipment actually required) the formula becomes $\frac{2{\cdot}5\,({\cdot}952M - a)}{a^1 - a}$ where $M =$ existing multiple equipment.

It sometimes happens that some of the answering equipment cannot be utilised for traffic reasons, say, in two years' time, and yet may be utilised later. We may therefore be faced with the problem of working to an overload for a definite time, after which conditions right themselves.

In the case of small exchanges in which no "B" positions are fitted, the incoming calling rate is equated (equating multiplier 1·16), and a composite calling rate obtained.

It is usual to consider dates of exhaustion from the point of view of "A" equipment only, but in some cases where it is known that the "B" capacity is the controlling factor a special study is made. In such cases the incoming traffic is multiplied by the equating multiplier applicable to the exchange, and the "B" positions are treated as "A" positions.

We have hitherto dealt with the extension of existing switchboard equipment or with new equipment replacing that which already exists. There are one or two problems associated with new exchange areas which may be of interest. The nucleus of new exchanges is usually composed of lines from adjacent exchange districts. If we are acquainted with what lines it is proposed to transfer initially to the new exchange, we can obtain a fair idea of what calling rate to expect. The calling rate of the new exchange will be a composite calling rate, possessing the characteristics of the calling rates of the various adjacent exchange districts which lose part of their areas. The existing building calling rate of the new exchange will be a weighted average, and its projection will depend upon the tendency of the past composite calling rate.

When we deal with such questions as the number of originating outgoing junction calls in the busy hour or the number of busy hour incoming junction calls, the problem is not so simple.

Suppose an exchange with a percentage of junction working y loses x per cent. of its traffic on account of the creation of a new exchange area.

Then $\frac{x\,y}{100} =$ calls transferred which will be made to exchanges other than that losing the traffic.

Also $x - \frac{x\,y}{100}$ represents the local calls which will be made among the lines transferred and the junction calls to the lines left on the exchange losing the lines. Further $\left(x - \frac{x\,y}{100}\right)\left(\frac{100 - x}{100}\right)$

represents the junction calls from the new exchange to the exchange losing the lines.

These formulæ are all expressed as a percentage of the total originating traffic at the exchange from which the lines are transferred.

EXAMPLE.—An exchange with 76 per cent. outgoing junction working loses 19 per cent. of its traffic to an exchange in a new area. What will be (1) the percentage of local working; (2) the percentage of junction working to the exchange losing the lines; (3) the percentage of junction working to the other exchanges in the area at the new exchange?

Expressed as a percentage of the total originating traffic at the exchange losing the lines, we have:

Percentage of junction working to the other exchanges in the area $= \frac{x\,y}{100} = \frac{19 \times 76}{100} = 14{\cdot}44.$

Percentage of junction working to the exchange losing the lines $= x\left(\frac{100 - y}{100}\right)\left(\frac{100 - x}{100}\right) = 19\left(\frac{100 - 76}{100}\right)\left(\frac{100 - 19}{100}\right) = \frac{19 \times 24 \times 81}{10{,}000} = 3{\cdot}69.$

Percentage of local working $= \left(x - \frac{x\,y}{100}\right) - 3{\cdot}69 = (19 - 14{\cdot}44) - 3{\cdot}69 = {\cdot}87.$

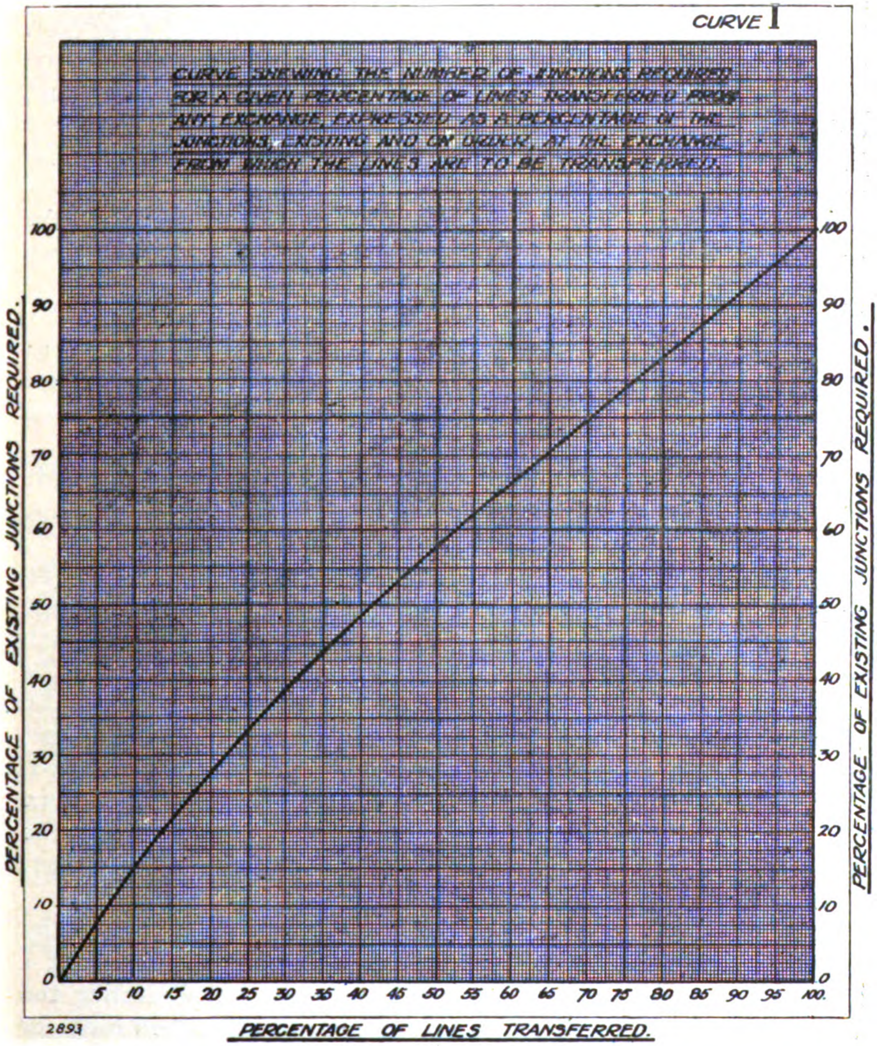
If we express these figures as percentages of the traffic at the new exchange we get (in the order in which the questions were asked): (1) 4·6 per cent., (2) 19·4 per cent., (3) 76 per cent.

Now if we know the past tendency of the calling rate and percentage of junction working, etc., at the exchange from which the lines are transferred, we can predict the calling rate, the percentage of junction working, the total junction traffic and its destination at the new exchange with comparative ease.

The nucleus of a new exchange is, however, seldom composed of lines transferred from one exchange. Usually several exchanges play a part, and our calculations, in consequence, become somewhat laborious. Not only have we to repeat the process illustrated in the above example for each exchange concerned in order to arrive at a composite figure, but we have to determine what proportion of traffic, at present junction traffic, will become local traffic.

The following formula is used when we wish to determine the local calls which will become junction calls at an exchange from which lines are transferred to create a new exchange: Let A represent the number of lines transferred, B the total lines, and R the local calling rate. Then the number of local calls which will become junction calls $= A \times \frac{R(B - A)}{B}$.

An exchange which loses lines to another should also lose a proportion of its junctions. It is not always possible to transfer all the junctions which the exchange should part with as shown by calculation. There may be engineering difficulties, and it may not be worth while doing so when the rate of development and the increasing traffic at the exchange losing the lines is taken into account.



Curve *I* helps us to ascertain what proportion of junctions is required in such cases.

Suppose an exchange with 1000 lines and 200 junctions is losing 16 per cent. of its lines. If we refer to the curve, it will be seen that 23 per cent. of the existing junctions are required at the new exchange. Now, obviously, the parent exchange cannot part with 23 per cent. of its junctions. Although forty-six junctions are required at the new exchange, only a definite proportion of these can be transferred. If we again refer to the curve, we find that for 84 per cent. of the lines which remain we shall require 86·5 per cent. of the original junction supply. In other words 173 out of the 200 junctions must remain on the parent exchange, which can, therefore, only lose twenty-seven junctions. Consequently, nineteen more junctions must be added to the new exchange in addition to those required between the two exchanges in question.

If the transfer is to be effected at some future date when the calling rate is estimated not to be the same as that which exists, we employ the following formula: $x = \frac{B\,D \times 100}{A\,C}$.

Where x = the percentage of existing junctions required, B = the number of lines to be transferred, D = the estimated busy hour junction calling rate at date of transfer, A = the number of existing lines, and C = the present busy hour junction calling rate.

On account of the length of this article, the writer can only give one or two notes relating to desk and miscellaneous exchange equipment.

EXCHANGE MANAGER'S DESK.—It is only in very large exchanges, under the existing conditions of management, that an Exchange Manager requires to be separated from his assistants. Under such conditions, he should be provided with a table apart from the standard desk. The two positions on this desk should be side by side, because the technical difficulties of providing face equipment and other apparatus at the rear of the desk (wider desk required, difficulty experienced in removing faults, etc.), more than balance the traffic advantages gained by the Exchange Manager having one side of the desk to himself. It should always be possible, however, to fit a shelf at the rear of the desk for clerical purposes.

SUPERVISOR'S DESK.—The two desk positions should be side by side for the reasons stated, and it should also be possible to fit a shelf at the rear of the desk. The traffic reasons for separating the Supervisor from her staff are probably more important than those for separating the Exchange Manager from his assistants because of the Supervisor's more frequent interviews with members of the operating staff on matters of discipline.

CLASS 1: ASSISTANT SUPERVISORS' DESKS.—The National Telephone Company did not provide these desks. During the last few years of its existence, however, there was a growing need felt at some of the larger exchanges for providing "Assistant Clerks-in-Charge" in order to relieve the "Clerk-in-Charge" of some of her numerous duties. The provision of these desks virtually splits up the exchange into a number of smaller exchanges, each under a first-class assistant supervisor, all of whom are responsible to the Supervisor, who can thus devote her time to the more important aspects of operating work.

MONITORS' (OR INFORMATION) DESK.—The general improvements which have lately been effected are:

(1) The employment of the ancillary system on enquiry lines, etc. This improves the team work, and concentration becomes easier.

(2) The economy effected by fitting the face equipment in panels between each pair of positions.

(3) The provision of a shelf at the rear for observation and other purposes.

(4) The lines to the "B" operators' head sets are not multiplied. The jacks are fitted at one end of the desk and are only used for observation purposes.

(5) An engaged test remains on an enquiry or complaint circuit, until the connection is taken down at the desk.

The existing monitorial load (fifty to sixty items) is considered too high. A great deal, however, depends upon the nature of the work. Some fresh time values should be obtained and a percentage of occupied time fixed.

The writer considers that the lines from the desk to an "'A' position" used by the Monitors when wishing to communicate with other exchanges should terminate on a jack-ended position where this exists. This will give the Monitor complete visual supervision, which does not exist at present on this class of connection.

According to the rules usually adopted, the following desk provision is made at exchanges of varying size:

Switchboard positions.	Desk provision.	Remarks.
Up to 4 . . .	Table and single instrument	In an exchange of this size the operator in charge operates at the switchboard for the greater portion of the day.
5 to 12 . . .	One-position desk (single pedestal)	Fitted with card index, docket distributor, ticket-collecting drawer, and docket file.
13 to 18 . . .	Combined Supervisor's and Monitor's desk (two positions)	Do.
19 to 40 . . .	One-position Supervisor's desk (double pedestal); separate Monitor's desk	The card index only is retained on the Supervisor's desk.
Over 40 . . .	Two-position Supervisor's desk; separate Monitor's desk	Do., unless an Exchange Manager's desk exists. Card index drawers can, however, be fitted at a future date if necessary.

Electrophone Position.—The number of electrophone junctions provided for varying numbers of electrophone subscribers on the central distribution system is generally considered excessive. The scale should be revised.

Testing Operator's Position.—The writer is in favour of fitting the keys associated with the plugging-up circuits in the panels. Their manipulation behind the cords is not difficult, and the space on the key-shelf is necessary for writing purposes. It is for this very reason that the testing keys are now fitted on the left of the key-shelf. Unless the subscribers' multiple is low, the best position for the voltmeter is in the panels below the multiple, and it should be fitted there even if a portion of the outgoing junction multiple has to be sacrificed. If the voltmeter is fitted on the key-shelf, very little space is left for records and for writing.

The writer wishes to make it clear that all the information given in this article will not alone enable an officer to deal with design work in an intelligent manner. Local experience is equally important, and this takes a considerable time to acquire.

His best thanks are due to Mr. Newitt, of the London Traffic Branch, for many results of his own personal investigations; to Mr. Maycock for providing him with various records; and to Mr. Thorpe for being good enough to draw the curves to which reference is made in the article.

APPENDIX No. 2.—"*B*" *Operators' Loads.*

Number of order wires incoming from one exchange.	Number of exchanges connected to the same order wire.	Busy hour loads.			
		London Telephone Service.		National Telephone Co.	
		Machine ringing.	Manual selective ringing.	Machine ringing.	Manual selective ringing.
6	—	500	459	490	—
5	—	500	458	475	—
4	—	490	447	460	420
3	—	470	427	440	400
2	—	440	402	410	375
1	1	390	351	350	315
—	2	330	296	340	305
—	3	290	259	325	290
—	4	250	221	300	265
—	5	220	191	—	—
Ringing junctions		190	190	—	200

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IMPROVEMENTS IN LONG-DISTANCE TELEPHONY.

By Prof. J. A. FLEMING, M.A., D.Sc., etc.

AN interesting and illuminative discourse was delivered by Prof. J. A. Fleming at the Royal Institution on Friday, March 27th, with the above heading. Unfortunately space is not available to publish the whole of the lecture in the JOURNAL.

The following extracts, however, describe Prof. Fleming's experiments with vibrating cords, which illustrate wave transmission along telephone lines in a beautiful manner.

DESCRIPTION OF THE CORD VIBRATING APPARATUS AND EXPERIMENTS DEMONSTRATING WAVE PROPAGATION OVER UNLOADED LINES.

We have on the shaft of a small electric motor a pulley which has a crank pin in it driving a crank shaft, the other end of this being attached to a rocking lever. A long cotton cord is fastened to a loop on the crank shaft, so that when the motor revolves one end of the cord has a circular but irrotational motion given to it. If the string is stretched horizontally by a weight passing over a pulley, we have a medium along which we can propagate waves. The string possesses elasticity and also density or mass, and in virtue of this can store up energy in two forms, potential and kinetic, and have waves of displacement propagated along it. When one end of it is revolved uniformly by the motor the rotation given to the end of the stretched string therefore travels along it as a wave of displacement. The speed with which this wave travels is directly proportional to the square root of the tension or pull on the string, and inversely as the square root of the weight of the string per unit of length.

If the length of the string is properly adjusted, the repeated waves produced by the revolution of the motor run up the string and are reflected at the fixed end, thus meeting the outgoing waves and making stationary waves on the string. By adjusting the tension we can alter their velocity, and therefore the wave length, or double the distance from node to node. The number of vibrations of the cord is given by a counter which records the speed of the motor. The motion travels along the string a distance equal to one wave length in the time of one complete vibration. We can with this apparatus experimentally prove all the above statements. Taking a string of known density or weight per inch or centimetre, and stretched by a known weight or tension, we can find the square root of the quotient of tension by density, which gives us the velocity of the wave, and compare this number with the measured product of wave length and frequency, which also gives us the wave velocity.

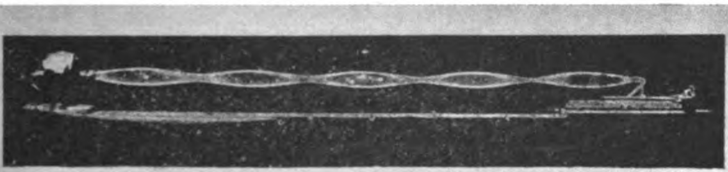
The two numbers are found to be the same. If we employ a string one-half of which is single and the other half four-fold, we find on vibrating it that the waves are double as long on the part which is single as they are on the part which is four-fold, thus proving that the velocity varies inversely as the square root of the density. By varying the speed of the motor whilst keeping the tension of the string constant, we can obtain stationary waves of various wave lengths, and prove that the velocity of the wave along the string is the same for all wave lengths (see IV).

In the case of this vibrating string, the mass per unit of length corresponds to the inductance of an electric cable, and the tension applied to the string to the inverse or reciprocal of the capacity of the cable, but if the string is very flexible there is no quality which corresponds to the electric resistance of the cable, or to its dielectric leakance. We must therefore turn for assistance to another case of wave motion.

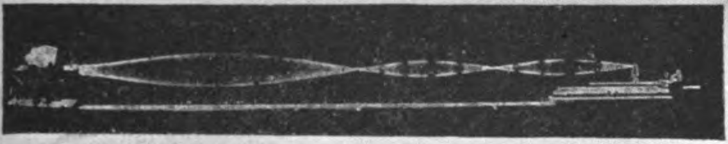
If we attach to a horizontal steel wire a number of strips of metal all soldered transversely to the wire, and if we give the end strip a sudden displacement so as to twist the steel wire one way or the opposite, a wave of twist, or a torsional wave, will run along it.

In this case the torsional elasticity of the wire corresponds to the tension in the case of the stretched string, and the mass of the system per unit of length to the density of the string. This latter corresponds also to the inductance of our telegraph cable, and the torsional elasticity to the reciprocal of the cable capacity per unit of length. If we suppose this arrangement to be immersed in water so that the oscillatory motion of each transverse strip is resisted, the water produces a decay or attenuation in the waves transmitted along it which corresponds to the action of the electrical resistance of the conductor in attenuating electric waves running along it. Moreover, it is clear, since fluid friction increases with velocity, the attenuation of the waves propagated along this arrangement would be greater for waves of short wave lengths or high frequency than for long waves of low frequency.

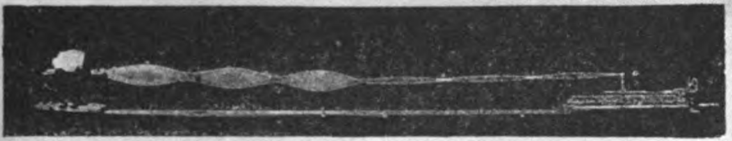
The point to notice is that by making these transverse strips heavier we can give them a greater store of energy, and thus render



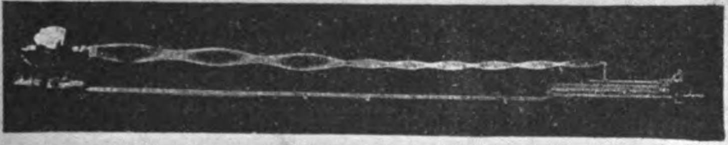
I.—Standing Waves on Unloaded String.



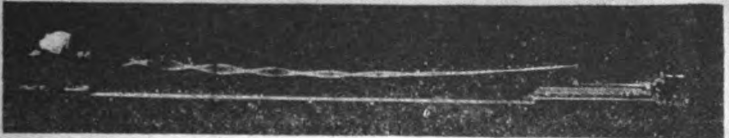
II.—Standing Waves on String Half Loaded, Half Unloaded.



III.—Reflection of Wave by Load at Centre of String.



IV.—Standing Waves on String Half Single, Half Fourfold.



V.—Standing Waves on Loaded String, Wave-length Covers about Three Loads.

Professor Fleming's Cord Vibrating Apparatus to illustrate Wave Propagation.

the effect of the fluid friction in retarding them less marked sensible. Again, if we suppose the steel wire to be imperfectly elastic and to possess in some degree a quality like pitch or wax of yielding to a slow steady stress, but not to a rapidly alternating one, it will be clear that slow vibrations or long waves of tension will be attenuated more in travelling up such a strip than quick vibrations or short waves. Such a quality of imperfect elasticity in the wire could correspond to conductivity or leakance in the dielection of a cable.

Hence, we may sum up all our statements with regard to an electric cable by saying that in virtue of its two energy-storing qualities—viz. the inductance and capacity—we can have waves of electric current or potential propagated along it just as we can have waves of twist or displacement propagated along a steel strip or a flexible thread. Also in consequence of its two energy-dissipating powers of conductor resistance and dielectric leakance, these electric waves along the cable are attenuated or weakened as they run along it by reason of the gradual dissipation of the energy.

LOADING AND THE CORRECT SPACING OF LOADING COILS IS DEMONSTRATED AS FOLLOWS:

If we place on a string a heavy glass bead somewhere about the middle and then set the string vibrating, we shall see quite easily that the wave is reflected at the bead and only a small portion of it transmitted. In the first section of the cord there are vigorous vibrations, but on the other side of the load they are very feeble (see III).

If we put on the string several beads, and adjust the tension and frequency of the vibrations so that the half wave length extends rather more than the distance which separates two adjacent beads, we shall notice that a reflection of the wave takes place at each bead which rapidly attenuates the wave (see V). Precisely the same thing takes place in the electrical case. Hence in practice it is found that the wave length on the cable must extend over eight or nine loading coils at least, these coils being placed at equal distances.

ILLUSTRATION OF REFLECTION.

When loaded cables are connected at their ends to land lines which are not loaded there is a certain loss of amplitude by the reflection which occurs at the junction where the two lines of different impedance join. This effect is exactly similar to that which occurs when a ray of light passes from one medium to another of different refractive index.

We can illustrate this phenomenon by use of our vibrating string. If we put a single heavy bead in the centre of our string and vibrate one end of it with the motor so to the make waves travel along it, you see that strong waves exist on one half of the string but very feeble ones on the other. When the waves meet the load they are partly transmitted and partly reflected, just as when a ray of light meets a sheet of glass (see II).

If we put several beads upon the string at distances comparable with the half wave length, then reflection takes place at each bead and the waves die away in amplitude very quickly.

If, however, we put beads of different sizes, beginning with a heavy bead in the centre and beads decreasing in mass on either side of it so as to make a tapered load, then the wave started at one end of the coil passes through the loads with much less loss by reflection.

The same thing happens in the case of the passage of a ray of light from one medium to another of different refractive index.

If the refractive index is graduated very evenly there will be refraction of the wave but less reflection.

We meet with identically the same phenomenon in the case of coil-loaded telephone cables. It is necessary to taper off the loading by increased spacing or gradual reduction of the inductance of the coils to reduce the losses by reflection when the waves pass from the coil-loaded cables to the unloaded terminal wires.

The discourse, which was printed and published by the Royal Institution, also contains interesting data of various loaded submarine and aerial lines, and some notes on wireless telephony.

B. S. C.

[*We are greatly indebted to Prof. Fleming for sending us a copy of the paper, with full permission to reproduce the whole or any portion of it in our pages.*—EDITORS, POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.]

BALANCING OF TELEPHONE CABLES WHICH REQUIRE TO BE LOADED FOR SUPERIMPOSED WORKING.

By S. A. POLLOCK, M.I.E.E.

(*Continued from p.* 66, *Part I, Vol. vii.*)

THE following example selections involving the additional wire-to-earth measurements of capacity may help to make the explanation given in the preceding contribution clear:

Suppose a core in sections 1–4 has the following measured values—

$$p = -2;\ q = -1;\ r = -2;\ s = -1,$$
$$u = -27;\ v = +105,$$

and a core in sections 5-8 the following values—

$$p = +2;\ q = +2;\ r = -1;\ s = -1,$$
$$u = +105;\ v = +28.$$

According to instructions we select at joint 4-5 for earth capacities only. Therefore, if we keep section 1-4 straight, making all crosses on section 5-6, we should cross *AB*, and pairs.

The residual out of balances on sections 1-8 will then be:

$$P = -3;\ Q = -2;\ R = -4;\ S = -3;$$
$$U = +1;\ V = 0.$$

Similarly, suppose a core on sections 9-12 has the following measured values—

$$p = 0;\ q = +1;\ r = -1;\ s = 0,$$
$$u = -44;\ v = +52,$$

and a core on sections 13-17 has the following measured values:

$$p = -2;\ q = -3;\ r = -1;\ s = -2,$$
$$u = +50;\ v = -47.$$

Then selecting for earth capacities at joint 12-13, and keeping sections 9-12 straight, making all crosses on sections 13-17, we should cross *AB*, *CD*, and pairs.

The residual out of balances on sections 9-17 will then be:

$$P = +2;\ Q = +2;\ R = +2;\ S = +2,$$
$$U = +3;\ V = +2.$$

A test is now made at joint 8-9 for both resultant capacities and earth capacities on sections 1-8, and 9-17.

Suppose the measured values are the residual out of balances we have just calculated, *i.e.* on sections 1-8,

$$p = -3;\ q = -2;\ r = -4;\ s = -3$$
$$u = +1;\ v = 0$$

and on sections 9-17,

$$p = +2;\ q = +2;\ r = +2;\ s = +2$$
$$u = +3;\ v = +2.$$

At joint 8-9 we select for resultant capacities only. We should therefore join straight through, and our residual out of balances on sections 1-17 will be:

$$P = -1;\ Q = 0;\ R = -2;\ S = -1$$
$$U = +4;\ V = +2.$$

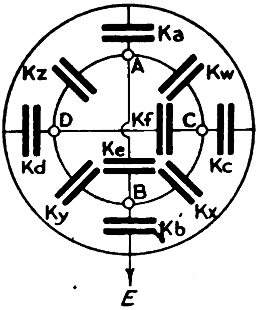
If, however, the measured values of the earth capacities had been large we should have taken them into account as well as the resultant capacities when selecting at joint 8-9.

Appendices I and II show the results obtained on a typical loading coil section of the Leeds-Hull cable containing twenty-six lengths by the system of testing and selection so far explained in this article.

The foregoing procedure, however, is restricted to the case of cables which are fairly symmetrical to start with, as may be gathered from the assumptions made in p. 62. When these assumptions are not approximately realised it is necessary to substitute for measurements of *resultant capacity differences* other measurements of the *true wire-to-wire* and *wire-to-earth capacity differences*. These measurements involve additional apparatus and additional time for testing and selecting. They need only be resorted to, however, where the more simple procedure results in appreciable discrepancies between the algebraic sum of resultant capacity differences and the actual re-measurements of lengths joined together.

The method of satisfactorily dealing with very unsymmetrical quads, such as may sometimes occur in a composite cable, or in the outer layer of a cable core having unusually high out-of-balance wire-to-earth capacities, will now be explained.

Referring to **6**, p. 50 (here reprinted), it will be seen that the capacities associated with a quad core form a complex mesh system presenting some difficulties in the measurement of the individual capacities, and also in the calculation of the new capacities when another similar mesh system is superposed upon it, as actually occurs when two quad cores in different lengths are joined together; the individual capacities in one core being connected in parallel with corresponding capacities in the other core. But for practical purposes it has been found that this complex system can be represented by a simpler one, even in the case of cables having excessive out-of-balance capacities, whether as wire-to-wire or wire-to-earth, and that such cables may be balanced to any assigned degree of perfection within practical limits of construction by selections made on that representation. Arrangements must be made in such cases to measure and select with the true wire-to-wire and the true wire-to-earth capacity differences instead of resultant capacity differences made up partly of wire-to-wire and partly of wire-to-earth capacities.



6.

To make such measurements a Wheatstone bridge arrangement having two pairs of capacity arms in addition to the usual ratio arms has been utilised; one pair of the capacity arms being used to balance the wire-to-wire capacities and the other pair to balance the wire-to-earth capacities simultaneously. One arrangement is shown in **14** and the other in **15**. Both these arrangements were developed for this purpose by Mr. C. E. Hay, of the Research Section, Engineer-in-Chief's Department, who was assisted in the investigation by Mr. H. T. Werren of the same Section.

The necessity for using the double bridge in exceptional cases was shown by Mr. C. E. Hay, who calculated the discrepancy in the case of networks each containing five capacities when these networks

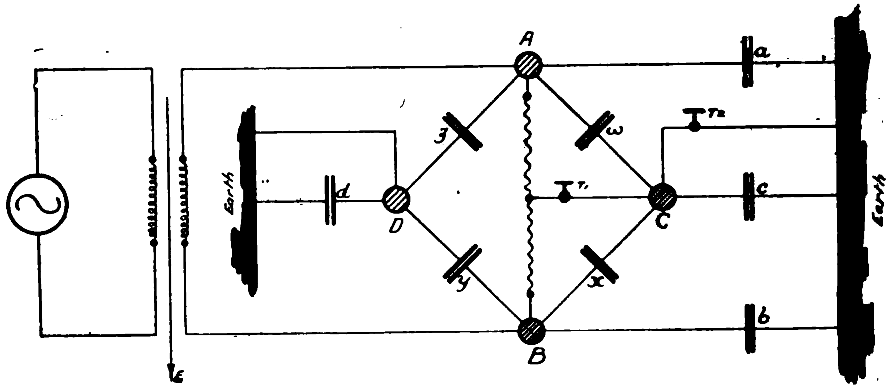


Fig 14.

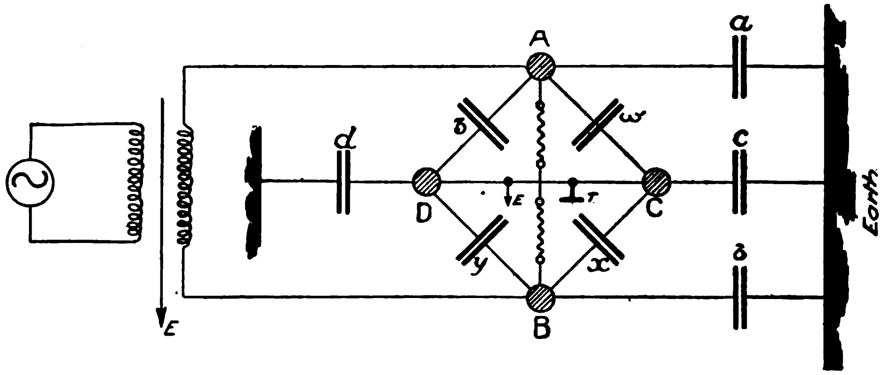


Fig. 15.

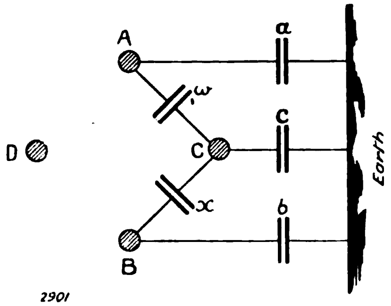


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Fig 16

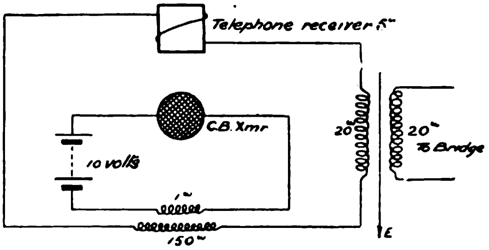


Fig 17

were separately measured as two resultant capacities, and the effect of joining them predicted by taking the algebraic sum of the resultants. **16** shows the diagram of capacities to which Mr. Hay's formulæ apply. If the wires AB are connected to the ratio arms oı a Wheatstone bridge supplied with a source of testing current, and a telephone is connected between the middle point on the ratio arms and the wire C, the arrangement constitutes a 5-mesh network in which the condition for no current in the telephone may be found in terms of the conductances a, b, c, w, x.

This condition is expressed by the following formula deduced by Mr. Hay:

$$x + b = w + a + \frac{(a + b)(w - x)}{c}.$$

If P represents the capacity which must be added to w or x to obtain a balance then

$$\pm P = (w - x) + c\,\frac{b - a}{a + b + c},$$

that is, the capacity to be added is equal to the sum of the difference of the *wire-to-wire* capacity and a fractional part involving the *wire-to-earth* capacity. If P_1 represents the capacity to be added in another similar network then the sum of these values will, of course, be $P + P_1$.

The method of selection previously explained had for its object the reduction of a similar sum to zero. The actual residual capacity when the two sections are joined together may not be $P + P_1$ exactly, but will be equal to:

$$(x + x_1) - (w + w_1) + \frac{(c + c_1)(b + b_1 - a - a_1)}{A + A_1}$$

where $A = a + b + c_1$ and $A_1 = a_1 + b_1 + c_1$

The difference between this expression and $P + P_1$ is;

$$\frac{c(b - a)}{A} + \frac{c_1(b_1 - a_1)}{A_1} - \frac{(c + c_1)(b + b_1 - a - a_1)}{A + A_1}$$

$$= \frac{(b - a)\left(\frac{A}{A_1}c_1 - c\right) + (b - a)\left(\frac{A_1}{A}c - c_1\right)}{A + A_1}$$

The discrepancy depends not merely upon the difference of the wire-to-earth capacities of the A and B wires in the same length, but also upon the difference of the C wires in different lengths. To calculate the discrepancies for each selection tried would be so slow and laborious as to become prohibitive. The practical alternative is to measure the true wire-to-wire differences $(w - x)$, $(z - y)$, $(w - z)$ and $(x - y)$ and the true wire-to-earth differences $(a - b)$ and $(c - d)$, and select simultaneously for the reduction of all these values to as near zero as possible. This is greatly facilitated by the relation which is found to exist between the signs of the true wire-to-wire characteristics and the true wire-to-earth differences. For example, when $(p + q)$ is positive $(a - b)$ is negative and *vice versa*. And similarly when $(r + s)$ is positive $(c - d)$ is negative. This means that any selection which reduces $(p + q)$ and $(r + s)$ also reduces $(a - b)$ and $(c - d)$ respectively. As this relationship does not hold with *resultant* values, simultaneous selections with such values are more restricted and much more difficult. For this reason the more convenient procedure when selecting with *resultant* values is that already explained in page 66.

One arrangement of apparatus for making true wire-to-wire and true wire-to-earth measurements is shown in **14**. In this arrangement balance is obtained when both telephones are silent simultaneously, and this is effected by varying the adjustable air condensers (a) and (w). This brings the centre of the ratio arms and the point C to zero or earth potential.

In the Wheatstone Bridge containing the telephone T_1 the conditions for balance when both telephones are silent is:

$$\frac{1}{R}(x\,\theta) = \frac{1}{R_1}(w\,\theta)$$

whence, for equal arms,

$$w = x \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In the Bridge containing the telephone T_2 the capacities a and z are in parallel, and so also are the capacities b and y, whilst the capacities c and d receive no charge when T_2 is silent; the points C and D being at zero potential. The condition for balance when both telephones are silent is then:

$$w\,(b + y) = x\,(a + z) \quad . \quad . \quad . \quad . \quad (2)$$

$$\text{From (1)} \qquad w = x$$

$$\therefore \; b + y = a + z$$

$$\text{or } w - x = 0$$

$$\text{and } z - y + a - b = 0$$

Similar conditions apply to the remaining three tests of each quad core. In practice it is convenient to use a double headgear telephone with one of the receivers in one of the telephone positions in the bridge, and the other receiver in the other telephone position. This arrangement is sensitive, simple, and capable of giving good results, but does not give the same facilities for rapid working as the arrangement shown in **15**.

In this diagram the capacities a, z, and one of the ratio arms are in parallel, and similarly b, y, and the other ratio arm. When the telephone is silent the point C is at zero potential, and consequently the capacity c receives no charge. Then:

$$\left[\frac{1}{R} + \theta\,(z + a)\right] \times \theta = \left[\frac{1}{R} + \theta\,(y + a)\right] w\,\theta,$$

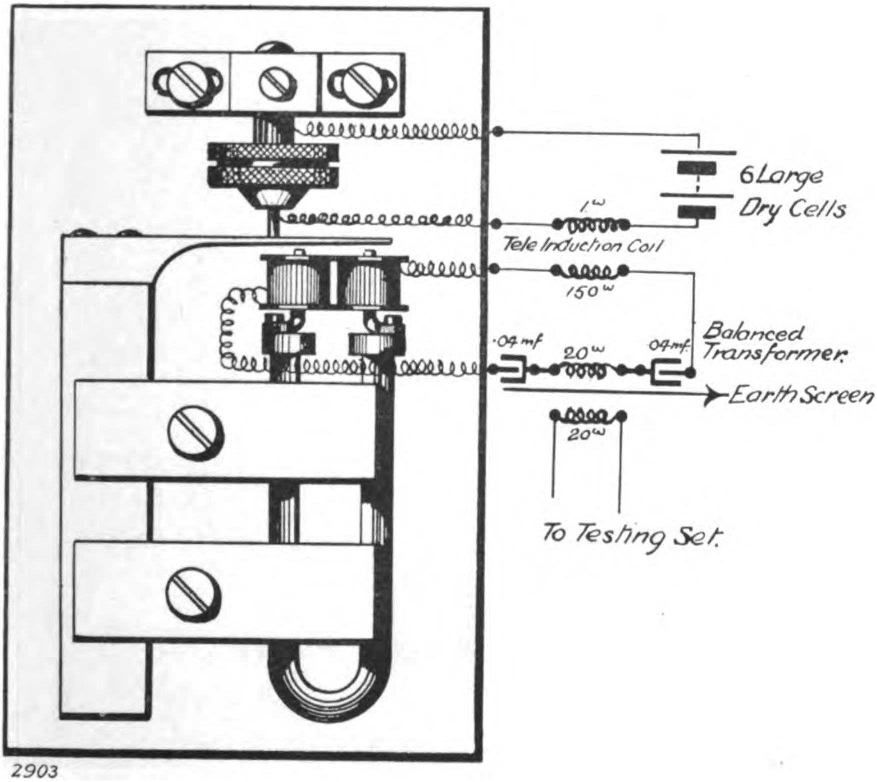
whence with equal ratio arms,

$$w - x = 0, \text{ and } z - y + a - b = 0.$$

This is identical with the result obtained for the arrangement shown in **14**. The four tests give :

(1) $w - x = 0$ and $z - y + a - b = 0$
(2) $z - y = 0$ and $w - x + a - b = 0$
(3) $w - z = 0$ and $x - y + c - d = 0$
(4) $x - y = 0$ and $w - z + c - d = 0$.

The first readings give directly the true wire-to-wire capacity differences, and from the second readings the true wire-to-earth capacity differences can be read off.

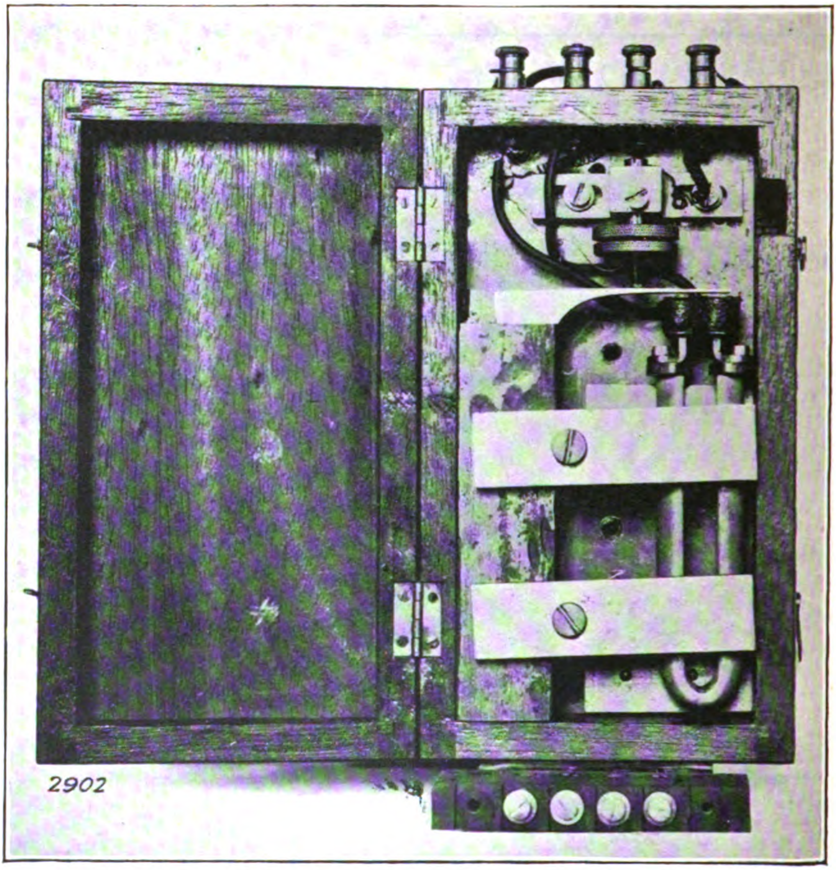


18.—Connections of Reed-Hummer.

The four simultaneous conditions for balance refer to the four tests which are made upon each quad core, *i.e.*:

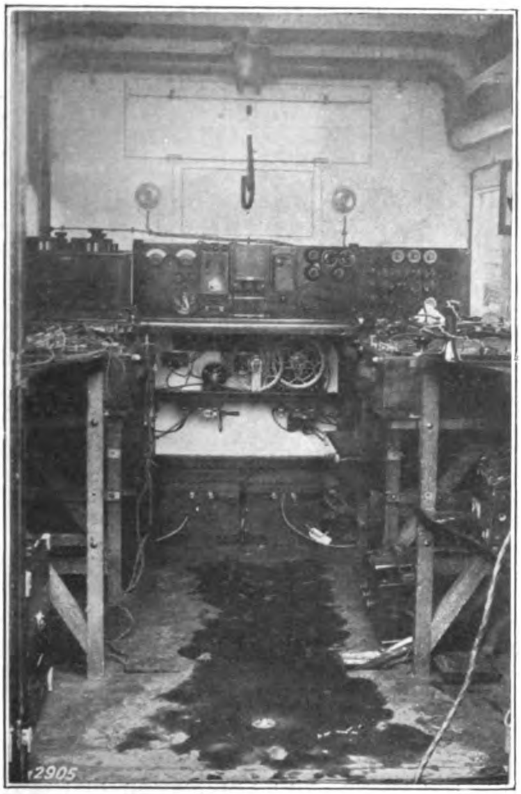
(1) *A* and *B* on bridge, *C* on telephone, *D* earthed.
(2) Ditto ,, *D* ,, *C* ,,
(3) *C* and *D* ,, *A* ,, *B* ,,
(4) Ditto ,, *B* ,, *A* ,,

It is very important in testing with this arrangement that the telephone be brought to perfect silence or errors in the earth capacity difference measurements will result. There is, however, no difficulty in obtaining perfect silence if the insulation and electro-static screening of the wire leads and apparatus have had proper attention. Bad contacts between the cable plugs and connectors or in the four-position switch will also result in erroneous earth capacity difference readings. For this reason the resistance of such contacts must be carefully watched and kept negligible. Improvements have recently



19.—Reed-Hummer designed and used by Engineer-in-Chief's Staff as a Generator of Testing Current.

been effected in the designs of a connector and switch to overcome this difficulty and to obtain a good capacity balance between the components of these items. A very low resistance earth connection from the testing apparatus to the sheath of the particular length of cable under test is essential for accurate wire-to-earth measurements, and there should be no breaks in the sheath, as, for example, at incomplete joints. The sensitivity of the double bridge arrangement for the wire-to-wire readings is about the same as with the single bridge, and for the wire-to-earth readings one part in 10,000 can be read on loading coil sections of 2½ miles in length when using 2000 ohm arms and the Reed hummer as a source of testing current. A photograph is given of this hummer, and **18** shows the original diagram of connections. **17** shows a modified diagram which was found to give more power in Mr. Hay's hands.



20.—Interior of Testing Van.

When using the double bridge set there is less trouble in securing a silent and fixed zero on the reading condensers by the use of screened wiring from the hummer to the balanced and screened transformer, and also from the latter to the bridge set, and by earthing the screens and negative pole of the hummer battery. "Stannos" wire is convenient and suitable for this purpose, though, of course, a lead sheathed, well insulated wire serves the purpose quite well.

Sufficient space is not available in this number to enter into the full discussion of the relation between cross-talk and capacity, resistance and leakance unbalances in the loading coil sections, but this will be dealt with in a future contribution. I take this opportunity, however, of acknowledging the valuable contributions of Messrs. C. Robinson, C. E. Hay, E. S. Ritter, and H. T. Werren to the present very perfect development of the theory and practical application of balancing methods. Passing over for the moment the numerous minor improvements in apparatus and application which have occurred, I may specially mention that Messrs. Ritter and Werren have largely contributed to the present rapid and convenient system of selection; Mr. Robinson effected the great improvement of substituting capacity difference measurements for capacity ratio measurements, and Mr. Hay, as already mentioned, is responsible for the theory and application of the double bridge to the simultaneous measurement of the true wire-to-wire and true wire-to-earth unbalances. I may say that we are not aware of any method having been previously published showing how this could be done in a direct manner.

21.—PORTABLE TESTING UNIT.

The photographs of the Department's new testing van (see **20** and *Frontispiece*) and of a recent design of a portable testing unit on a tripod will doubtless be of interest.

ERRATA.

Vol. 7, Part 1, page 46, equation (10) should read $W = X = Y = Z$.

Page 54. Table I, fifth column, first line, should read $-Q - P - S - R$.

Page 55, Table II, fifth column, fourth line, should read $x - w = -p$, and fourth column, sixth line, should read $w - x = p$.

APPENDIX I.—*Schedule showing Tests of the Outside Layer of Twenty-six Lengths comprising a Complete Loading Coil Section.*

Colour of core.		Numbers of lengths.												
		1	2	3	4	5	6	7	8	9	10	11	12	13
R—1 .	*p*	− 3	−17	−11	+ 7	+ 3	+25	+ 2	− 4	+ 4	+11	− 5	+ 6	+ 5
	q	− 4	−18	−11	+ 6	+ 4	+20	+ 1	− 1	+ 6	+ 9	− 3	+ 6	+ 7
	r	− 6	+26	0	+20	+30	+ 1	+ 7	+11	− 4	− 3	−11	−10	−10
	s	− 7	+25	0	+19	+31	− 4	+ 6	+13	− 3	− 5	− 9	−10	− 9
W—1 .	*p*	+14	−21	− 6	− 8	−17	0	− 2	+ 8	−15	−11	+ 3	−12	+14
	q	+11	−20	− 4	− 9	−13	− 1	− 5	+10	−15	−10	+ 5	−11	+12
	r	− 6	+ 9	+ 3	+10	+14	+ 2	+ 5	+ 4	− 1	−30	−12	+ 3	0
	s	− 9	+ 9	+ 5	+ 9	+18	+ 1	+ 2	+ 5	− 1	−28	−10	+ 4	− 2
B—1 .	*p*	+ 2	+24	+15	+18	+22	+18	+ 2	+14	+14	+13	+ 1	+13	+15
	q	+ 6	+27	+17	+18	+22	+18	+ 1	+13	+13	+13	+12	+11	+14
	r	+ 9	− 4	−10	− 2	+ 1	+ 2	+16	+11	+ 7	− 5	+15	− 4	− 4
	s	+13	− 2	− 7	− 2	+ 1	+ 2	+15	+10	+ 6	− 5	+16	− 6	− 5
G—1 .	*p*	− 4	+10	+ 5	+ 4	− 1	− 6	+11	+ 2	− 4	+ 8	+26	+11	−17
	q	− 3	+ 8	+ 4	+ 5	− 2	− 6	+10	+ 5	− 7	+ 5	+24	+12	− 5
	r	− 3	+ 1	+ 4	+ 7	+10	+14	+ 6	−13	−16	+ 5	+ 3	−15	+21
	s	− 2	− 1	+ 2	+ 8	+ 9	+14	+ 5	−10	−19	+ 3	+ 2	−13	+23
O—1 .	*p*	+ 5	− 4	− 8	− 2	− 2	+ 1	− 3	+30	− 1	− 5	+ 8	0	− 4
	q	+ 4	− 6	− 6	+ 2	+ 3	− 1	− 6	+29	− 1	−11	+ 9	+ 3	− 3
	r	− 4	−12	−13	− 2	− 7	+ 3	+ 1	− 5	+ 1	+ 4	0	+ 1	− 2
	s	− 5	−14	−11	+ 2	− 3	+ 1	− 2	− 6	0	− 3	+ 1	+ 4	0
R—2 .	*p*	+12	+11	+ 3	+ 8	+11	+ 4	+19	+19	+13	+21	+ 3	+ 5	+ 7
	q	+12	+13	+ 5	+ 7	+13	+ 5	+14	+16	+13	+19	0	+ 6	+ 9
	r	+ 3	+13	+ 9	+22	+ 6	+ 7	− 3	+ 5	+ 8	− 3	− 4	− 4	− 3
	s	+ 3	+14	+11	+21	+ 8	+ 9	− 8	+ 2	+ 8	− 5	− 7	− 3	− 1
W—2 .	*p*	+ 6	− 6	−13	−11	− 8	− 1	− 4	−20	+ 1	+15	+ 4	+10	+17
	q	+ 5	− 1	−12	−11	−11	− 1	− 3	−23	0	+19	+ 8	+ 8	+19
	r	− 6	−16	−11	− 8	− 4	+ 8	+14	+ 5	+ 7	−33	−21	− 5	− 6
	s	− 7	−11	−10	− 8	− 8	+ 7	+14	+ 3	+ 6	+29	−17	− 7	− 4
B—2 .	*p*	+ 9	+21	+16	+21	+23	−16	+ 5	+20	+ 7	+ 9	+15	+16	+17
	q	+11	+22	+17	+21	+23	−16	+ 4	+20	+ 6	+14	+13	+14	+17
	r	− 2	+22	+17	+ 3	0	+ 4	− 1	+ 8	−11	+20	+ 2	− 3	−11
	s	0	+22	+18	+ 2	0	+ 4	− 2	+ 8	−11	+24	+ 1	− 6	−11
G—2 .	*p*	+ 3	−10	−13	−20	− 1	+16	− 5	− 4	+ 1	+22	+ 4	− 1	− 5
	q	+ 3	− 8	−13	−20	− 2	+17	− 5	− 5	0	+22	+ 2	− 2	− 2
	r	+ 5	−16	−12	− 9	− 4	+18	+16	−11	− 6	+ 4	+ 2	+23	+14
	s	+ 5	−14	−12	− 9	− 4	+19	+15	−12	− 8	+ 5	− 1	+22	+16
O—2 .	*p*	+ 2	− 8	− 5	− 6	− 4	− 4	+ 4	+ 2	+ 8	0	− 5	− 1	+ 4
	q	+ 5	− 8	− 8	− 6	− 8	+ 2	− 3	− 1	+ 8	− 6	− 9	− 4	+ 5
	r	+ 3	− 2	+ 5	−20	−15	− 5	+ 5	+ 3	− 4	− 6	− 5	+ 2	+ 3
	s	+ 6	− 2	+ 3	−20	−20	+ 1	− 2	0	− 3	−12	− 9	0	+ 4
R—3 .	*p*	+ 5	+13	+15	+26	+27	+ 3	− 2	+18	+ 4	− 7	+15	+11	+ 6
	q	+ 3	+14	+15	+27	+27	+ 4	+ 1	+23	+ 3	− 6	+17	+11	+ 6
	r	+12	− 4	− 7	− 5	+ 4	+ 4	+ 3	+ 6	+ 4	− 5	− 5	− 4	− 6
	s	+ 9	− 3	− 7	− 4	+ 4	+ 5	+ 5	+11	+ 4	− 4	− 3	− 4	− 6
W—3 .	*p*	+ 2	−20	−16	−20	−12	− 5	+ 1	+ 7	+ 4	+ 3	+ 8	+12	−17
	q	− 6	−21	−15	−17	−10	− 5	+ 3	+ 8	+ 7	+ 2	+11	+10	−17
	r	− 1	+16	+14	+10	+ 9	− 2	+ 1	+17	+ 5	− 6	−33	− 7	+ 1
	s	− 9	+14	+15	+13	+12	− 2	+ 2	+17	+ 8	− 7	−30	− 9	+ 2
B—3 .	*p*	− 4	+26	+16	+21	+24	+ 9	−20	+17	+11	− 1	+ 4	+19	+12
	q	− 9	+29	+18	+22	+23	+11	−20	+19	+11	+ 4	+ 5	+20	+11
	r	−10	+ 9	+17	− 2	− 3	+15	+ 1	−18	+ 3	+ 8	+20	−13	− 4
	s	−15	+11	+19	− 1	− 4	+16	+ 1	−16	+ 3	+13	+21	−12	− 6
G—3 .	*p*	− 9	+11	+ 3	+13	+12	+14	+ 7	− 3	+ 2	+28	+15	+ 1	+20
	q	− 5	+ 8	+ 4	+12	+12	+12	+ 8	− 2	+ 2	+27	+15	+ 5	+20
	r	+ 9	+ 1	− 8	− 4	− 6	+ 8	+15	− 3	− 6	− 4	− 3	+22	− 8
	s	+12	− 2	− 7	− 5	− 6	+ 5	+16	− 2	− 6	− 5	− 3	+26	− 8
O—3 .	*p*	+ 5	− 8	−10	0	+ 4	+ 5	+ 7	+ 7	+20	+ 5	+ 5	+ 4	+ 2
	q	+ 5	−11	−12	+ 1	+ 3	+ 6	+ 2	+ 9	+18	+ 7	+ 1	+ 1	+ 5
	r	−13	−14	−17	+17	+ 6	0	+ 3	− 2	0	− 1	− 8	− 1	− 5
	s	−13	−17	−18	+18	+ 4	+ 1	− 3	+ 1	− 2	0	−11	− 4	− 2

APPENDIX I—*continued.*

Colour of core.		Numbers of lengths.												
		14	15	16	17	18	19	20	21	22	23	24	25	26
R—1 .	*p*	+8	+6	+12	−10	+15	+7	+12	−3	−12	+10	+22	0	−10
	q	+9	+7	+14	−9	+16	+9	+12	−2	−8	+12	+10	0	−7
	r	+8	−9	−6	−5	−1	−2	+4	+12	+4	+3	+18	+25	+2
	s	+9	−9	−5	−4	0	0	+4	+13	+8	+5	+6	+25	+5
W—1 .	*p*	−39	−7	−2	+10	−5	−13	−9	+3	−8	+7	−7	−10	−7
	q	−37	−5	−3	+12	−6	−13	−10	+1	−8	+10	−11	−10	−11
	r	+10	+4	+2	−7	−11	−34	−27	+20	−0	−29	−9	−29	−36
	s	+12	+6	+1	−6	−12	−34	−29	+18	−8	−26	+5	−29	−41
B—1 .	*p*	0	+17	−22	+14	−5	−27	−21	+14	+9	+8	−4	−8	−5
	q	0	+18	−28	+15	−6	−24	−21	+14	+9	+11	−4	−7	−4
	r	−19	−15	−9	−10	−14	+19	+19	−25	−2	−6	+19	+5	−9
	s	−19	−14	−15	−10	−15	+22	+19	−25	−1	−3	+19	+6	−8
G—1 .	*p*	+12	−16	0	0	−21	−24	−20	−1	+11	−29	+13	+1	−7
	q	+10	−13	+3	0	−21	−22	−18	+4	+12	−25	+9	+2	−4
	r	−12	+28	−11	−1	−4	+33	+33	+22	0	+28	−1	−15	−22
	s	−14	+32	−8	−1	−4	+35	+34	+27	0	+31	−5	−13	−19
O—1 .	*p*	+3	+3	−1	0	+4	−13	−14	−7	−17	+11	+19	+1	+1
	q	0	+4	+6	0	+6	−10	−7	−10	−20	+11	+18	−2	−1
	r	+8	+3	−6	−1	+7	+4	+4	−12	−14	−2	−12	−3	−1
	s	+5	+4	+2	−1	+8	+7	+10	−14	−17	−2	−13	−6	−3
R—2 .	*p*	+11	+9	−5	+9	+9	−4	−6	+9	0	+1	+5	−9	−16
	q	+13	+13	−10	+9	+8	−4	−5	+9	−1	+2	+1	−14	−22
	r	−18	+6	+9	−4	−3	+8	+4	+6	+1	+12	−3	+1	+5
	s	−15	+10	+6	−4	−5	+8	+5	+6	0	+13	−6	−4	0
W—2 .	*p*	−7	−5	−3	−1	+11	−6	−6	−2	+2	−15	−14	+2	−14
	q	−10	−3	+4	−6	+9	−8	−8	−1	−1	−11	−13	+1	−13
	r	+10	−4	+24	−3	−6	−11	−16	+18	+22	+6	+8	−48	−16
	s	+7	−2	+30	−8	−9	−12	−18	+19	+19	+10	+10	−50	−15
B—2 .	*p*	+21	−7	−29	−21	+9	−3	+3	−6	+17	−1	−20	−10	−14
	q	+20	−7	−20	−23	+11	−2	+2	−8	+17	+2	−20	−9	−17
	r	−23	+2	−6	−8	+9	+22	+13	−1	−6	+27	+5	−16	+6
	s	−23	+2	−7	−10	+12	+22	+12	−3	−6	+30	+5	−16	+3
G—2 .	*p*	−7	+13	−2	+6	+1	−16	−5	0	+3	+5	−25	−7	0
	q	−3	+19	0	+10	+2	−15	−9	+1	+4	+5	−22	−7	+1
	r	+34	+21	+16	−9	−8	+16	+33	+20	+16	−5	+21	−16	−34
	s	+37	+26	+17	−6	−6	+17	+30	+21	+18	−5	+23	−15	−32
O—2 .	*p*	+5	−2	+4	+3	−2	−1	−9	+5	−10	+16	+4	+6	+5
	q	0	−1	+4	+2	−3	−2	−9	+4	−14	+19	+2	+5	+2
	r	+1	+7	+4	+1	+4	0	0	−10	−14	−14	−2	−7	−6
	s	−5	+9	+4	0	+3	−1	0	−10	−18	−10	−4	−8	−9
R—3 .	*p*	+20	+10	−23	−10	+6	+12	+11	−18	−12	−7	+7	−15	−5
	q	+23	+10	−19	−13	+4	+12	+13	−16	+11	−6	+9	−11	−5
	r	+15	+14	−3	+11	+5	+6	−3	+9	+5	−4	+4	0	+21
	s	+18	+14	0	+9	+4	+5	−1	+11	+4	−3	+6	+4	+21
W—3 .	*p*	−20	−28	+4	−9	−15	−3	−6	+1	+7	−16	+14	−20	−5
	q	−19	−26	+9	−4	−17	−2	−6	0	+7	−16	+8	−24	−3
	r	−2	+12	−11	+16	−15	−10	−19	−8	+28	+5	−23	−16	−39
	s	0	+14	−7	+21	−17	−9	−19	−8	+28	+5	−19	−20	−38
B—3 .	*p*	−3	0	+15	−19	+35	+3	+3	+7	−15	−22	+14	−14	−7
	q	−1	−3	+16	−23	+37	+2	+2	+10	−11	−19	+13	−13	−4
	r	−5	−9	−14	−3	−4	−2	+1	−7	+2	+3	−5	+2	−4
	s	−3	−12	−13	−7	−2	−3	0	−3	+6	+6	−6	+3	−1
G—3 .	*p*	+17	+6	+4	0	+7	+6	+7	+17	+2	−11	−20	+5	+2
	q	+19	+6	+5	+1	+8	+7	+7	+20	+1	−8	−12	+8	+6
	r	+20	−16	−1	+19	+4	−11	−18	+5	+23	+16	+24	−31	−7
	s	+22	−16	−1	+20	+4	−11	−18	+7	+33	+19	+32	−29	−3
O—3 .	*p*	+1	+7	+1	−3	+6	−5	−2	−14	−6	−7	+3	−2	0
	q	−1	+7	−1	−2	+9	−3	+3	−20	+6	−4	+5	+3	−2
	r	+14	+16	+2	+3	+7	−3	−4	−13	−19	−3	−6	−4	−3
	s	+12	+15	0	+4	+10	−2	+1	−18	−7	0	−4	0	−5

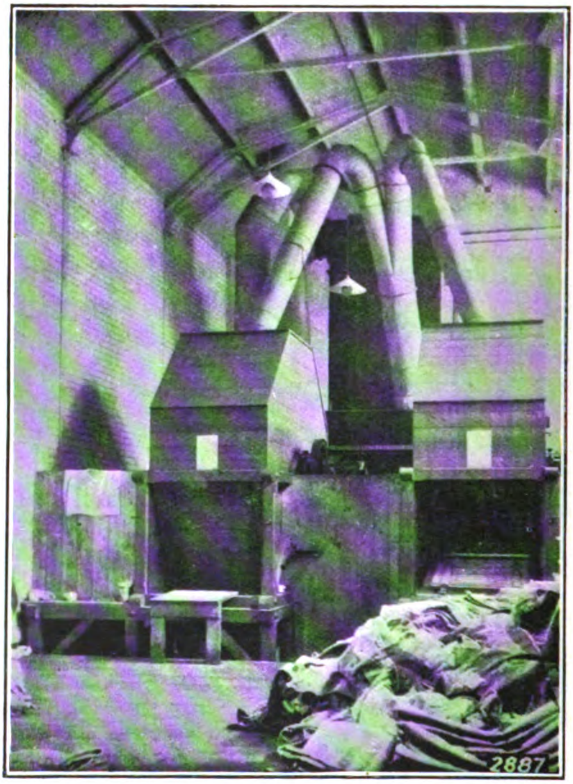
APPENDIX II.—*Schedule showing Tests* (1) *after Joining up into Sections of Four or Five Lengths;* (2) *after these have been Joined into Sections of Eight or Nine Lengths; and* (3) *of Complete Loading Coil Section.*

Colour of core at end tested.		1						2			3
		Nos. of lengths.						Nos. of lengths.			Nos. of length
		1-4	5-8	9 13	14-18	19—22	23-26	1-8	9-18	19-26	1-26.
R—1 .	*p*	0	−2	0	−3	+2	+2	+1	−1	−1	−2
	q	0	−1	−2	0	+1	−2	+1	−1	0	−2
	r	+3	−1	0	0	+1	0	−2	+1	−2	0
	s	+2	0	−2	+3	0	−4	−2	+1	−1	0
W—1 .	*p*	−2	−2	−1	+5	−2	−1	0	0	0	−2
	q	−1	+1	0	+3	−2	0	−1	0	−4	−1
	r	−2	0	+1	+3	−2	−2	−3	0	−1	+1
	s	−1	+3	+2	+1	−2	−1	−4	0	−4	+2
B—1 .	*p*	−4	−3	0	0	−2	+1	−2	−2	−2	+2
	q	−3	0	0	+3	−1	+2	−1	−3	+2	0
	r	+1	−2	0	+2	+1	0	−1	−1	−5	+2
	s	+2	+1	0	+5	+2	+1	0	−1	−1	0
G—1 .	*p*	−2	−1	−1	+1	−2	−2	−1	+2	−1	−3
	q	0	−2	+1	0	−2	−2	0	+1	−1	−2
	r	+1	+1	−4	0	0	+2	−2	+2	−1	0
	s	+3	0	−2	−1	0	+2	−1	+1	−1	+1
O—1 .	*p*	−3	−1	0	+1	+6	0	−1	−1	−4	0
	q	+4	−1	+1	0	+3	+5	+2	−1	−3	0
	r	0	−1	0	0	+2	−4	−1	−1	+1	−2
	s	+6	−1	+1	−1	0	0	+2	−1	+2	−2
R—2 .	*p*	+1	+1	+1	−1	0	−2	+1	+2	+1	−3
	q	−1	+1	0	0	0	−1	0	0	0	−1
	r	+1	+1	+1	0	0	−1	−1	+1	+1	−1
	s	−1	+1	0	+1	0	0	−2	−1	0	+1
W—2 .	*p*	−1	0	−3	0	0	0	−4	0	+3	−2
	q	+2	0	−1	−2	+2	0	−2	0	+1	0
	r	+2	+1	−1	+2	−3	−2	−1	−1	−2	0
	s	+5	+1	+1	+1	−1	−2	+1	−1	−4	+2
B—2 .	*p*	+2	+1	+1	+8	+3	−8	0	−1	0	+2
	q	+1	+1	0	+6	+5	−2	+1	+1	+1	−4
	r	0	−2	+3	+3	−1	−5	−2	−2	0	+1
	s	−1	−2	+2	+1	+1	+1	0	0	0	−5
G—2 .	*p*	−2	0	−2	+1	−1	0	+1	−1	0	0
	q	0	+2	−4	0	−2	−1	0	−2	−1	0
	r	+2	−1	−9	+3	−2	−1	−1	−1	−2	−1
	s	+4	+1	−10	+2	−4	−2	−1	−2	−3	0
O—2 .	*p*	−1	−3	+4	0	+1	0	−2	+2	0	−2
	q	+2	0	+3	−1	−4	−1	0	−1	−1	−2
	r	−2	+1	+2	+3	+3	+2	−1	+3	−1	−1
	s	0	+5	+1	+2	−2	+1	+2	0	−2	0
R—3 .	*p*	+1	0	0	−1	−1	−5	+1	+1	+1	0
	q	0	−2	+1	−3	0	−1	+1	−4	−2	0
	r	+1	+3	−3	+2	0	−9	0	0	+2	−1
	s	0	+1	−2	0	+2	−5	+1	−5	−2	−1
W—3 .	*p*	0	0	−1	0	−2	−3	0	+1	+1	+1
	q	0	+1	−1	−1	−2	−1	0	+1	0	0
	r	+1	+1	+1	+1	+2	−5	−1	0	0	0
	s	+1	+2	+2	0	+2	−3	−1	−1	−1	−1
B—3 .	*p*	0	+2	−2	−2	−3	+6	+3	0	0	0
	q	−1	0	−2	0	−3	+3	+2	+1	+2	+1
	r	+2	+1	+2	+1	0	+3	+1	0	−3	−4
	s	+1	−1	+2	+3	−1	+1	0	+1	0	−2
G—3 .	*p*	+1	0	+2	+1	0	−3	+1	−3	−1	0
	q	+1	0	+3	+1	−1	−4	−1	−1	−2	0
	r	+1	+1	+4	+4	0	+2	0	−2	0	−2
	s	+1	+2	+5	+4	−1	+1	−2	0	−1	−2
O—3 .	*p*	−4	0	0	−3	0	−3	−4	−1	0	0
	q	−5	−2	+2	+2	+1	0	−2	−2	+1	+1
	r	+5	−1	0	−3	−3	0	+3	−1	0	0
	s	+4	−3	+3	+2	−2	+3	+4	−2	+1	+2

BAG-CLEANING MACHINES.

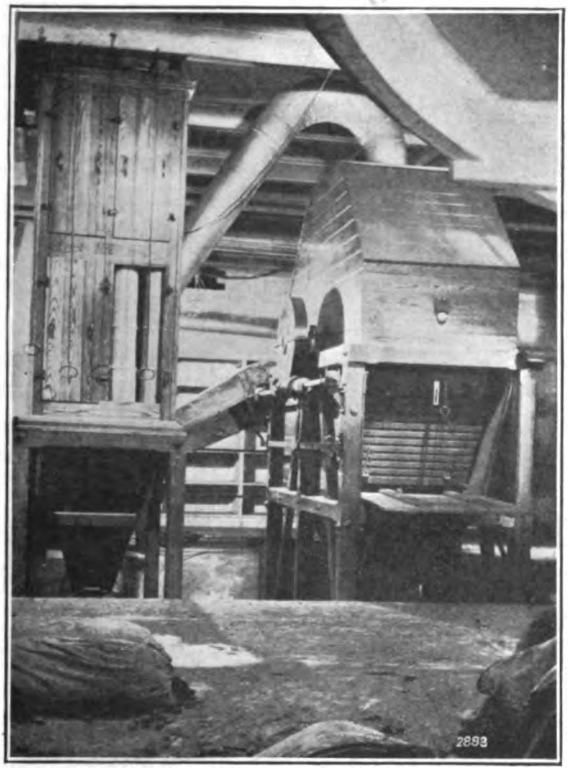
By E. H. WALTERS.

THE first practical steps in connection with the adoption of mail bag-cleaning machines by the British Post Office were initiated at Mount Pleasant Sorting Office, some six or seven years ago, by the installation there of an experimental machine. This machine was designed by this Department and built by the Mount Pleasant Factory, and with some modifications has been at work ever since. More recently machines have been installed at King Edward Building, and as a result of the satisfactory results obtained in both cases the number of installations is being gradually extended. Five are already completed and in use; four more are in course of construction, and it is understood that a total of about twenty installations is contemplated. The installation at King Edward Building is the largest one yet adopted and is capable of dealing with 400



KING EDWARD BUILDING BAG-CLEANING MACHINE.

bags per hour; the size of machine adopted for Provincial offices deals with 200 per hour. The principle is exactly the same in each case; the dirty bags are shaken up in a large rotating drum, the dust at the same time being drawn off by a fan through a dust filter, and the air only discharged to atmosphere. The illustration of the Glasgow plant shows the drum on the right hand side with loading and unloading flap open and the filter on the left, the electric motor, fan and driving gear being at the back of the filter.



Glasgow H.P.O. Bag-cleaning Machine.

The fan is direct coupled to the motor, which also drives the drum through belt and worm gearing. The filter is of the canvas hose type, the dust-laden air being drawn by the action of the fan from the outside to the inside of a number of lengths of canvas hose suspended vertically in a wooden case—two of these hoses can be clearly seen in the photograph, one of the doors having been removed for this purpose. In order to clean the hoses, shaking gear is provided, and arrangements are also made for reversing the air-current while they are being shaken. The dust liberated falls into a hopper, and thence into a closed paper bag, which can readily be removed and burned.

As these machines are mostly installed in the basements of Post Office buildings, in which clerical and other offices are also situated, special care has been necessary to avoid complaints of nuisance from noise, dust, and vibration. It is understood that the present installations are quite satisfactory in this respect, and that their use has resulted in a considerable improvement in the conditions under which bag sorters and others have to work.

HEADQUARTERS NOTES.

An interesting extension of the Baudot system has been made recently. A London-Glasgow underground line is now working as a quadruple duplex Baudot circuit (eight channels).

A repeater wired to Diagram *TG* 93, a description of which appears in this number of the Journal, has been installed at Warrington with very satisfactory results (see Mr. Booth's article, 7 and 8).

Daily totals of over 2000 messages are being obtained already, and it is expected that when the staffs have become thoroughly conversant with the system these figures will be largely exceeded.

Telephone Development.

C.B. Manual Exchanges.—The following new exchanges have been opened:

Exchange.	Date of opening.	Number of subscribers' lines. Exchange equipped for.	At date of opening.
Truro	28 : ix : '14	200	158
Cleckheaton	7 : xi : '14	360	274
Smethwick	7 : xi : '14	300	230

Automatic Exchanges.—The Darlington Exchange (Western Electric Company's Automatic system) was taken into use on October 10th, 1914. A description of this system was published in the Journal for July last.

The Newport Exchange (Automatic Telephone Manufacturing Company's system) is completed, and the whole of the trunk circuits were transferred thereto on November 21st, 1914. The subscribers' circuits now working to the Newport, Maindee and P.O. Exchanges will be connected to the automatic equipment on the completion of the underground cabling scheme.

NEW TYPES OF SWITCHBOARDS FOR COMMON BATTERY PRIVATE BRANCH EXCHANGES.

THE many points of difference in the design of the standard private branch exchange switchboards of the Department and of the National Telephone Co., and the corresponding lack of uniformity in the facilities which they afforded, have made it necessary to reconsider the whole question of the design of this apparatus, with a view to determining the standard types to be adopted for future work.

The following main principles were laid down and have served as a basis for the new designs:

(1) Speaking keys, or their equivalent, shall be provided on all boards, in order that the branch exchange operator shall be able to listen-in on any connection as desired.

(2) An audible alarm shall be provided on the supervisory signals of all boards having a capacity up to and including five exchange lines and twenty extensions.

(3) On boards having a capacity not exceeding ten lines in all, the extension station shall control simultaneously the supervisory signals both at the main exchange and at the branch exchange.

(4) On boards having a capacity for more than ten lines in all, the extension station shall control only the supervisory signal at the branch exchange, the exchange line being "held" so long as it is engaged at the P.B.X. This enables the extension stations to get incoming calls transferred to other extensions when desired.

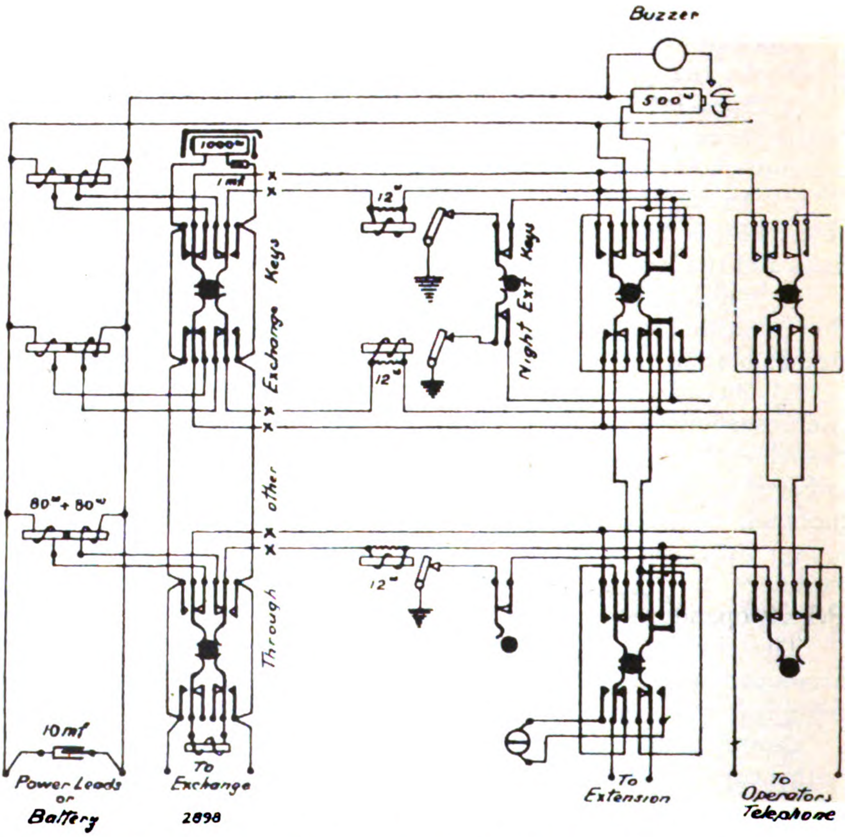
(5) Provision shall be made on all boards for giving direct exchange service at night to any extension independent of the P.B.X. operator.

The circuit arrangements of the new boards are shown in the accompanying diagrams, and the following brief notes indicate the main features of each type.

CORDLESS (1).—These will be made standard for all installations with a capacity up to ten lines. They will be available in the following sizes:

1 exchange line and 3 extensions.
2 ,, lines and 4 ,,
3 ,, ,, 7 ,,

When a connection is set up, the extension line signal is controlled by a series relay and acts as a supervisory signal. This secures two advantages: (1) a positive supervisory signal with an audible alarm is obtained, and (2) the supervisory signals are directly in line with the keys on which the connection is established. Night connections are provided for by means of a special key in connection with each connecting circuit, which, when thrown, renders the supervisory signals inoperative. The substitution of a relay with a non-inductive winding in place of the series eyeball signal formerly included in the connecting circuit provides improved transmission and signalling conditions. The extension station cannot call in the private branch exchange operator to transfer incoming calls without at the same time giving false supervisory signals at the main exchange, since the extension station clears simultaneously at the main and branch exchanges.

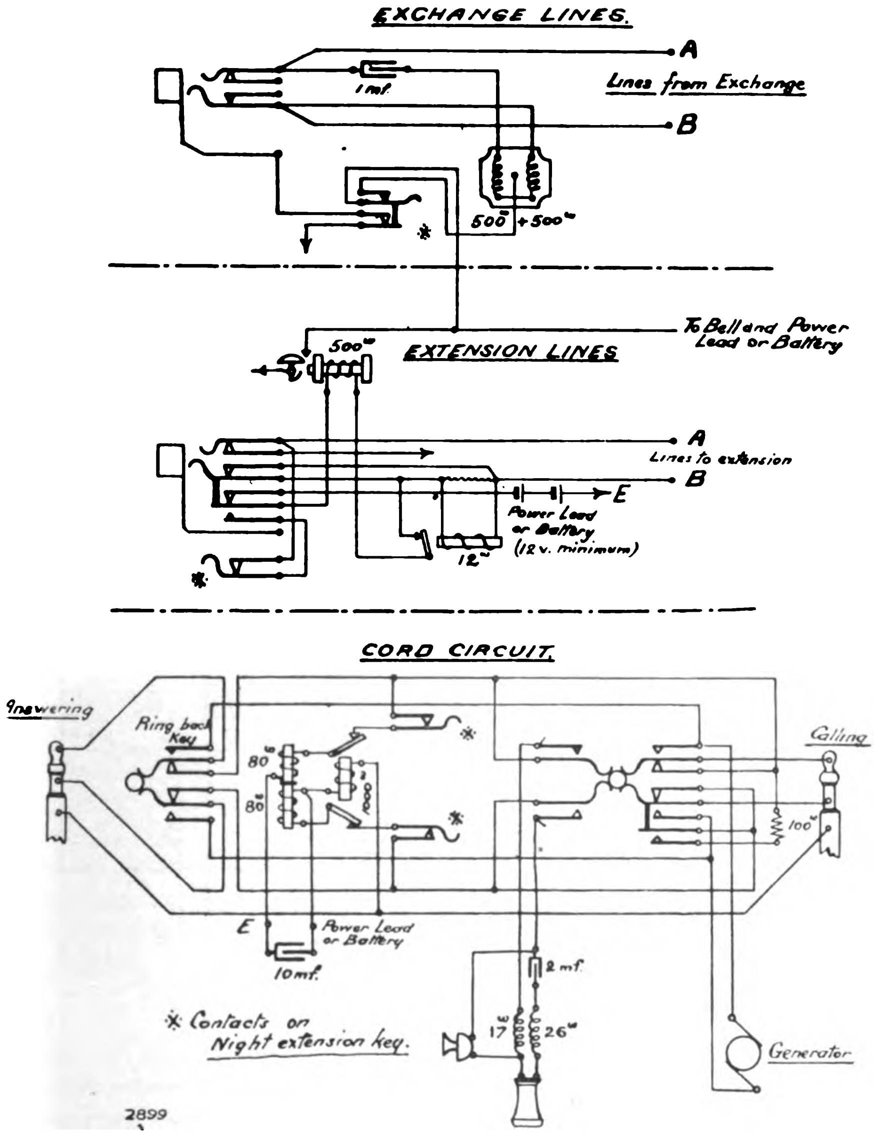


1.—Cordless Boards with Positive Clearing to Main and Branch Exchanges.

Double Cord Board (2).—These are floor type boards, opening from the front so as to permit of their being fitted against a wall. The frames will be wired for an ultimate capacity of five exchange lines and twenty extensions. They will be stocked in two sizes with the following equipments :

3 exchange lines and 10 extensions.
5 ,, ,, 20 ,,

The circuit arrangements are very similar to those of the cordless boards described above. The extension station in this case, however, controls the branch exchange supervisory signal

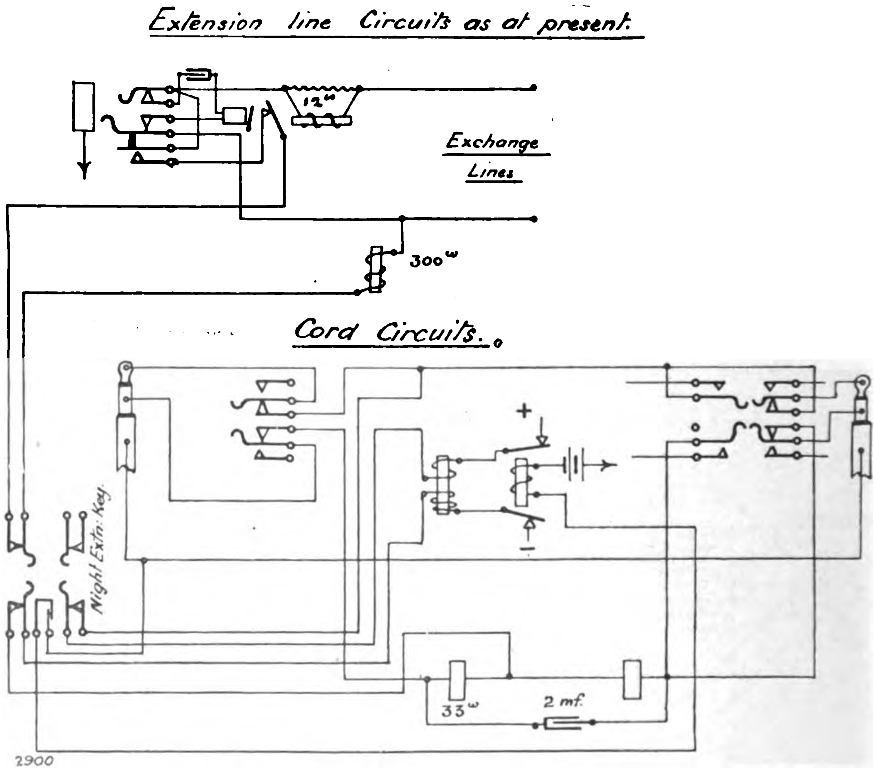


2.—Boards with Capacity of 25 Lines. Positive Clearing to Branch Exchange.

only; the exchange line is held by the P.B.X. operator's telephone and by the eyeball signal on the extension line until the extension replies, and from the time the extension hangs up until the P.B.X. operator clears by the eyeball signal. There is no holding coil across the line during conversation. These arrangements permit the extension to get incoming calls transferred without giving false signals at the main exchange.

Night working is provided for by means of a common key for the whole board which disconnects power from the cord circuits and breaks the circuit of the extension line eyeball, which would otherwise act as a holding coil.

Double Cord Board (3).—These are the ordinary floor type



3.—Boards with Capacity of 65 Lines.

boards, on which access to the apparatus is gained from the rear. The frames will be wired for an ultimate capacity of fifteen exchange lines and fifty extensions. They will be stocked in two sizes with the following equipments:

10 exchange lines and 30 extensions.
10 ,, ,, 50 ,,

The holding coil is associated with the exchange line jack, and is cut out of circuit during conversation by a series relay. Negative supervisory signals are provided; they are bridged by a condenser in order to provide better transmission conditions. As the exchange line is "held" at the branch exchange, the extension station can get incoming calls transferred without disturbing the connection at the main exchange. Night service is provided for by a common night switching key, which disconnects power from the cord circuits and breaks the circuit of the holding coils on the exchange lines. A cord-testing jack is fitted.

H. S. T.

LONDON DISTRICT NOTES.

NEW BUILDINGS IN PROGRESS.

CHARTERHOUSE EXCHANGE.—The contractors have started work upon this new 10,000 line exchange, and it is expected that the building will be completed by July, 1915.

TOLL EXCHANGE.—The internal modification of the building which has been acquired at Norwich Street, Fetter Lane, for the purpose of providing a new Toll Exchange is proceeding, and the structural alterations will probably be completed by the time these notes appear.

HOLBORN EXCHANGE.—The building long known as the Inns of Court Hotel has been acquired by the Department, and will be internally modified to provide a new Holborn Exchange. The reconstruction work has not yet commenced, but it is interesting to note that the main hall is serving a useful purpose in providing a drill ground for the London Welsh Battalion.

BATTERSEA EXCHANGE.—The purchase of a new site for an exchange at Battersea, which will replace the present Kellogg (2-wire multiple) Exchange, the only one of its kind in London, has been arranged.

EXCHANGE EXTENSIONS.

Extensions of exchanges are being carried out at, or are in hand for, Hammersmith, Chiswick, Streatham, Sydenham, Putney, East Ham, East, Brixton, Finchley, Hampstead, Walthamstow, and Wimbledon.

VICTORIA EXCHANGE.—It has been decided to instal a second 40-volt battery at Victoria. This will obviate the necessity for charging and discharging simultaneously, which operation in the case of a 40-volt exchange has a deleterious effect on the lamps, owing to wide voltage variations.

EXCHANGE MODIFICATIONS.

CITY, CENTRAL, AND TRUNKS.—Alterations are being carried out to improve the intercommunication of the power plants for the three exchanges—City, Central, and Trunks—which are all located under one roof.

LONDON WALL.—In 1911 a number of plug shelves at London Wall Exchange were fitted with hard rubber in place of the original leather which had become very worn. The hard rubber, which has the appearance of red fibre, has proved a great success, and its use is being extended.

STOCK EXCHANGE.—Considerable alterations and additions are being made in the telephone arrangements for the Stock Exchange. The telephones have hitherto been grouped in three separate rooms. Three additional rooms are now being provided, two of which are actually on the floor of the House. Formerly 58 lines and 50 cabinets existed. The new installation will consist of 114 lines and 89 cabinets. The various groups of lines will be controlled by attendants in the employment of the Department, and suitable enclosures are being provided for these. An intercommunication system will enable the supervising attendant to communicate readily with his staff. The alteration in the telephone system is being carried out in conjunction with the rebuilding of the Threadneedle Street Post Office.

MISCELLANEOUS.

ADMIRALTY: PRIVATE BRANCH EXCHANGE.—The contractors have started work on the installation of an eleven-position P.B.X. The switchboard is of the No. 12 type with an ultimate multiple capacity of 800, the present equipment being for 700.

A fire alarm system is being installed at the headquarters of the Controller, L.T.S.

Telephone House is being re-wired for telephone and electric clocks.

NEW TELEPHONE LINES.

During the thirteen weeks ending October 27th, 3336 exchange lines, 2607 internal extensions, and 211 external extensions were fitted. In the same period 3001 exchange lines, 1820 internal extensions, and 186 external extensions were recovered, making a net increase of 335 exchange lines, 887 internal extensions, and 36 external extensions. The relatively small increase for this period is, of course, due to the outbreak of war. The arrested development, however, has only been temporary, and the figures are now resuming their normal character.

EXTERNAL CONSTRUCTION.

For the three months ending October 31st, 1914, the net increase in exchange wire mileage of the London Engineering District was 14,372 miles, the increase under the head of Underground being 15,392 miles, whilst the Open (bare wire) and Open (aërial cable) decreased by 233 and 787 miles respectively.

Trunk wire mileage increased by 819 miles, but telegraphs decreased by 395 miles.

Pole line mileage increased by 11 miles, while pipe line increased by 64 miles.

The aggregate mileage for the London Engineering District at the end of October, 1914, under the various services are as follows:

Route Mileage.

Pole line	2458
Pipe line	3300

The total length of cables in the District is now 6894 miles.

Single Wire Mileage (including Spares).

Telegraphs	21,657
Telephone exchange	930,564
Telephone trunks	29,100

It will be observed that the grand total of mileage of wire is now just approaching one million miles.

REMOVING UNDERGROUND PLANT IN BLOCK.—Another successful diversion of underground plant has been effected in South London, in connection with the Wandsworth High Street widening, consequent upon tramway construction. Three pipes—one 4 in. and two 3 in.—each containing large main cables, were successfully removed over a distance of 180 yards. The trenches were opened throughout their length and bridged for the safety of the public. On early closing day the bridges were removed and the pipes lifted from the old trench. Unfortunately, the working conditions were bad. Rain, wind, sleet, mud, and poor light tried the temper of the workmen considerably. As a result the work had to be stopped and re-started on Sunday morning. Fortunately the weather conditions were more favourable, and the pipes were transferred without mishap. Pressure tests were made on the following day, with good results, and no faults have been reported up to date.

"WAYLEAVE RECORDS."—An incident of an unusual character is reported from the South-West Section. It is stated that when a gang went to remove a pole from a garden, the occupants of the house begged them to desist, as the pole was looked upon as an old friend and would be purchased if allowed to remain. This, apparently, is a new version of "Woodman, spare that tree."

UNIFICATION.—A good example of the advantage resulting from the unification of the telephone systems in London is afforded by the reconstruction scheme now approaching completion in the South-West Section of the Paddington area, extending over a considerable district, bounded by Bayswater Road on the south, Edgware Road on the east, Harrow Road on the north, and Porchester Terrace on the west. Practically all the aërial cables erected by the National Telephone Co., a great majority of which were nearing the end of their life, and consequently causing costly maintenance, have been recovered, and the circuits are now provided by means of underground cable. An astonishingly small amount of new underground construction has been necessary for this purpose, the Department's existing mains providing almost the whole of the required accommodation.

WITH THE COLOURS.—The number of officers in the London District who have joined the Colours up to the end of November was 975.

In connection with the Post Office Relief Fund, committees have been formed in each of the Sections for the purpose of dealing with claims upon the Fund and of keeping in touch with the families of those who have joined the Forces.

At Headquarters, and at each of the Sectional Headquarters, a complete list is displayed of all the men who have taken up military service.

We regret to add that already thirteen members of the District Staff have lost their lives in connection with the war. Their names and rank appear in the Post Office Circulars, and in the list printed on page 410.

THE PRESS BUREAU.

THE official bureau for the distribution of war news is now located at the United Service Institution, Whitehall, the actual typing of the information circulated being carried out within the walls of the well-known museum, amid the relics and trophies of past wars.

The Lecture Hall of the Institution has been set apart for the use of the press representatives, and here twenty-two cabinets of standard call-office type, each equipped with a telephone connected direct to Victoria exchange and boldly inscribed with the title of the newspaper, group of newspapers, or press agency to which it is allotted, are lined round a structural curve, and strike a dominating note. Within the main body of the hall the pressmen spend many waiting hours, smoking, chatting, reading and card playing. A smaller section has been partitioned to serve as a writing room. This part of the bureau is governed by a joint committee of officials and pressmen.

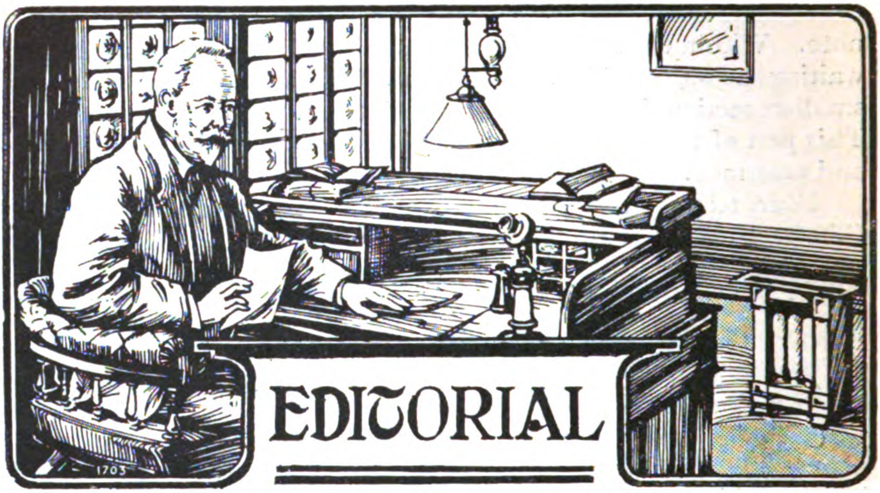
Four telegraph (sounder) sets and a pneumatic tube to the C.T.O. have been supplied by the department, which has also equipped and operates a $\frac{10 + 30}{60}$ C.B. switchboard to deal with the telephone traffic of the administrative and censorial side of the bureau.

The method of distributing news, as regulated by the joint committee already referred to, is somewhat as follows:

Well in advance of issue the probable time and the approximate word total is prominently displayed upon a blackboard. One minute prior to the circulation a bell rings, whereupon any cabinet in use is at once vacated, all telephone receivers being first restored to their resting positions. A very occasional offender attempting to steal a few minutes start from his compeers by retaining telephonic connection with his office receives physical attention from the committee. As soon as the cabinets are isolated, a bureau official distributes typed copies of the official information and not until every copy is placed is the signal given which precipitates every man to his particular cabinet.

Connections to newspaper offices are speedily established, the space held in reserve upon receipt of the blackboard's earlier intimation is filled, and the "News—OFFICIAL"—is on the streets.

A. C. GREENING.



EDITORIAL NOTES AND COMMENTS.

In this country there are at present two distinct divisions of industrial activity, one in which the production and distribution of commodities associated with the arts of peace is proceeding on almost normal lines, the other engaged in the preparation of military equipment, which is increasing in volume day by day as the demand for munitions of war rises with the growth of the new armies.

The engineering branch of the Post Office is representative of the purely industrial side of the nation, perhaps more so than any other department of State, and it is a remarkable evidence of the confidence of the authorities in our financial position and in the final issue of the war that little or no arrestment has been made in the progress of telephone and telegraph developments. Underground cable schemes for the telephoning of town areas, the extension of trunk facilities, and the installation and opening of new exchanges are proceeding practically as though no state of war existed. It would be interesting and instructive to ascertain the present position of the Vienna telephone schemes, a description of which was supplied to us by the Engineer-in-Chief of the Austrian administration, and appeared in the July issue of this volume. The article has an interest that is almost pathetic to telephone men, as the Austrian authorities had hoped to complete the automatic equipment of the Lemberg exchange—or should we now say the Lvoff exchange—before the end of 1914, and thereby place that town on the same terms telephonically as its sister city, Cracow. Let us hope, even at the risk of being considered unpatriotic, that no shells have penetrated to the intricacies of the pre-selectors!

It is not only on the telegraph and telephone side that progress has to be reported. The contract for the first section of the P.O. London Tube Railway has been placed with Messrs. Mowlem & Co., and work on the tunnelling has begun. The tube will cross the Edgware Road from Paddington at a depth of 87 ft., and will run for a portion of its length parallel with the "Tuppeny" Tube, which it will cross over under New Oxford Street, and pass under again at New Broad Street. Beyond Liverpool Street the tube will be driven underneath the Metropolitan Railway, and will pass over the East London Railway near Whitechapel Road. Contracts have not yet been placed for the electrical equipment, but the tests on the model experimental line at Woolwich prove that the proposed method of operating the trucks by distant control can be accomplished satisfactorily. We hope to give a detailed description of the system later.

Although we have said above that development work is proceeding normally, the statement requires qualification, as by the nature of things it is not possible for the *personnel* of the staff to be unaffected by the war. In addition to the officers who have volunteered for special duties, the mobilisation of the reserve and territorial forces called away many men to the services, and a large number have enlisted since mobilisation. The following list gives the number of men serving with the Colours for the period ended November 27th:

Statement showing number of officers withdrawn from the Engineering Department for military or naval service:

Engineering officers	30
Chief inspectors	14
Senior inspectors	12
Inspectors	27
Clerical officers	412
Skilled workmen (established)	476
Skilled workmen (unestablished), labourers, etc.	3527
Other grades	78
Total	4576

There are, in addition to the above, 103 Royal Engineers withdrawn from Ireland for service with the Army.

The under-mentioned members of the Institution hold commissioned rank:

A. C. Booth, Major, R.E., T.F. Signal Service.
H. Brown, Captain, R.E., T.F. Signal Service.
W. M. Batchelor, Captain, temporary in R.E., Regular Army.
G. H. Comport, Captain, temporary in R.E., Regular Army.
C. S. Wolstenholme, Lieutenant, Durham L.I.
W. J. Gwilliam, Lieutenant, temporary in R.E., Regular Army.
J. R. Kingston, Lieutenant, R.E., T.F.
H. F. Picker, Lieutenant, R.E., T.F.
A. S. Angwin, Major, R.E., T.F.
J. Lockhart, Captain, R.E., T.F.

F. Reid, Lieutenant, R.E., T.F.
A. Evans, Lieutenant, R.E., T.F.
F. G. Turner, Lieutenant, R.E., T.F.
H. C. Hannam Clark, Lieutenant, R.E., T.F.
J. Legg, Lieutenant, R.E., T.F.
H. Carter, Lieutenant, R.E., T.F.
P. J. Cottle, Lieutenant, R.E., T.F.
E. A. Lewis, Major, R.E., T.F.

C. R. McGowan's appointment as a lieutenant in the R.E., T.F., was also gazetted, but he had previously gone to the front with the H.A.C.

MENTIONED IN DESPATCHES.

T. J. Scaife, Corporal, R.E., Skilled Workman, Class II.

An account of the gallantry of Corporal Scaife is given under Northern District Centre Notes on p. 389.

We extend a hearty welcome to the 'Telegraph and Telephone Journal,' the latest product of the semi-official literary exuberance of the Post Office staff. The field covered by the activities of the Post Office *communication* services is wide enough to afford it plenty of space for developing existence, and if its able editors maintain the standard reached in the two opening numbers, now before us, there should be no doubt as to its permanent success. The new journal is issued monthly, and it caters mainly for the administrative and "traffic" sides of the telegraph and telephone services. At the same time its pages will be found to be full of interest to "engineering" readers, and we gather that it has already established a considerable *clientèle* in the Engineering Department. The scope and objects of the journal are well explained in an opening leader by our popular and well-beloved Second Secretary, Colonel Ogilvie, from whose remarks we take the liberty of quoting the following paragraph :

" A telephone journal is no novelty. Those who were readers of 'The National Telephone Journal' in the past know how much good service it did in promoting sympathy and co-operation among the members of the Company's staff. Our Journal aims at doing no less, but it will work in a wider field. The Telephone Exchange Service is expanding year by year. It is now united with the Trunk Service as a single organisation, and the Telephone Service, as a whole, now works in close relation with the Telegraph Service. The action and reaction of the ideas and influences of the two services must have an important effect on both, and the fostering of this influence will be one main object of our Journal. We shall not interfere with the work of other Post Office periodicals. We shall not deal with technical subjects from an engineering standpoint.

When such matters are touched upon, the subject will be to illustrate the practical manipulation of plant or the organisation of traffic. THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, of which, as a Department, we may be proud, must remain the recognised exponent of engineering subjects. The historical, biographical, and literary side of the Post Office, now so pleasingly dealt with in the pages of 'St. Martin's-le-Grand,' will still remain the peculiar field of that magazine. The appearance of our Journal will not, we believe, cause the loss of a single subscriber to either of these excellent periodicals. On the contrary the increase in the unity of the Post Office Service, which it is our aim to foster, will bring added support to all kindred movements."

COUNCIL NOTES.

OWING to the general pressure of work caused by the war it was not possible to hold the usual Autumn Meeting of the Council this year.

It is satisfactory to note that most of the provincial centres have been able to arrange a programme of meetings for the current session, but it is feared that in one or two districts which are specially affected by the war it will not be possible to do so.

T. SMERDON,
Secretary.

PROGRAMME: SESSION 1914-1915.

LONDON CENTRE.

1914.

October 19th.—" Ethics of Supervision." A. S. Renshaw.

November 16th { " Stores Accounting." W. T. Harris.
" Cash Accounting." W. J. A. Payne.

December 21st.—" Power Circuit Interference with Telegraphs and Telephones." S. C. Bartholomew.

1915.

January 18th.—" Telephone Relays and their Application to Commercial Circuits." C. Robinson.

February 15th.—" Wireless Call Devices." L. B. Turner.

March 15th.—" Telephone Economics: Open Construction." Harvey A. Smith.

April 19th.—Annual General Meeting.

NORTH-EASTERN CENTRE.

1914.

October 13th.—" The Engineering Department, Past, Present, and Future." T. B. Johnson.

November 10th.—" Building Materials used by the British P. O. Engineering Department." L. Tanner.

December 8th.—" Devolution and its Effects." S. A. Pickering.

1915.

January 12th.—" Notes on Telephone Development." C. S. Wolstenholme.

February 9th.—(Subject later.) E. S. Francis.

March 9th.—" Underground Works." G. H. Vernon.

SCOTLAND EAST CENTRE.

1914.
November .—"Heavy Construction, Perth to Stonehaven." F. Atkins.
December .—"C.B.S. Telephone Exchanges." J. T. Gillespie.
1915.
January .—"Correspondence." D. McLachlan.
February .—(Subject later.) A. B. Gilbert.

NORTH MIDLAND CENTRE.

Six papers promised, but no dates decided upon at present.

NORTHERN CENTRE.

1914.
October 21st.—"The Regulation of Plant Supply." F. G. C. Baldwin.
November 18th.—"Laying of Cables over Bridges." W. M. Batchelor.
December 17th.—"Darlington Auto Exchange," Part I. E. D. Wilkie.
1915.
January 2nd.—"Darlington Auto Exchange," Part II. E. D. Wilkie.
February 18th.—"Checking a Telephone Development Study." F. W. Gaskins.
March 18th.—(Subject later.)

SOUTH WALES CENTRE.

1914.
October 12th.—"Clerical Division of Sectional Engineers' Office." A. G. Packer.
November 9th.—"Maintenance of a C.B. Exchange." W. J. Shipton.
December 14th.—"Financial Comparisons of Schemes." F. Stevens.
1915.
January 11th.—"Telephone Transmission." E. L. Heyne.
February 8th.—(Not yet arranged.)
March 8th.—"Newport Auto Exchange." J. H. M. Wakefield and J. Radford.

EASTERN CENTRE.

No programme owing to war.

IRELAND CENTRE.

No programme owing to war.

NORTH WALES CENTRE.

1914.
November 17th.—"New Fault Record System for Local Exchanges." T. Plummer.
December 15th.—"Development." W. C. Burbidge.
1915.
April 20th.—(Subject later.) N. F. Cave-Brown-Cave.

NORTH-WESTERN CENTRE.

1914.
October 19th.—"Notes on Heavy Line Construction." J. W. Ray, A.M.I.E.E.
November 16th.—"The Training of Boys and Youths in Engineering Duties." H. G. Adams.
December 14th.—"Earth Resistances." W. Moon.
1915.
January 11th.—"Maps, Plans, and Diagrams." J. Sinclair Terras, A.M.I.E.E.
February 8th.—"Multiple Way Duct Work." D. C. Savory.
March 8th.—"Office Organization and Management." R. A. Jones.
April 12th.—"Direct Underground Distribution for Small Towns and Residential Suburbs." W. J. Rolfe.
Visit to Accrington new Automatic Telephone Exchange. Date to be arranged later.

SOUTH LANCASHIRE CENTRE.

1914.
November 2nd. { Inaugural Address. W. J Medlyn.
"Notes from an Engineer's Pocket Book." A. Magnall.
December 7th.* { "Telegraph Systems of South American Railways." G. H. Vaughan.
"Telephone Construction." R. B. Graham,

1915.

January 11th.—"Training of Workmen." D. Levy.
February 1st.*—"Notes on Underground Construction." A. J. Pratt.
March 1st.—"Instrument Fitting in a Large City." J. Hayward.
„ 29th.—"Telephone Faults." J. G. Whittle.

* Visits to works will be arranged on these dates.

LOCAL CENTRE NOTES.

LONDON CENTRE.

In spite of the fact that many of the members of the Engineering Department are engaged on civil and military duties connected with the war, there has been but a slight decrease in the attendance at the meetings.

The exigencies of the Service rendered it impossible to open the session with Mr. Turner's paper as had been originally arranged, and the first meeting was therefore devoted to the reading of a paper on "The Ethics of Supervision" by Mr. A. S. Renshaw.

A lengthy summary of Mr. Renshaw's paper and the discussion appear in this issue.

The November meeting was especially noticeable for the large number of members of the Clerical Staff who attended. Messrs. W. T. Harris and W. J. A. Payne read papers on "Stores Accounting" and "Cash Accounting" respectively, and the discussion was opened by the Engineer-in-Chief.

It is to be hoped that other members of the Clerical Staff will follow the example set by Messrs. Renshaw, Harris, and Payne, and contribute papers to the Institution.

Members will be glad to learn that the Postmaster-General has been pleased to intimate his intention of being present at the January meeting.

NORTH-WESTERN CENTRE.

The meetings will be held in the Lecture Hall of the Preston Scientific Society, Fishergate, Preston.

The opening meeting of the 1914–15 Session was held on October 19th, 1914, when Mr. J. W. Ray, A.M.I.E.E., read a paper entitled "Notes on Heavy Line Construction." Mr. T. E. P. Stretche, Superintending Engineer, presided over a good attendance of members and associates. The Chairman in the course of his opening remarks referred to the interesting programme which had been arranged, and expressed the hope that the meetings would continue to be well attended and the various points brought forward freely discussed.

Mr. Ray dealt with the various phases of heavy line construction, and touched upon many points not covered by the official instructions. The paper was profusely illustrated by an excellent series of lantern slides, and provoked an animated discussion.

On November 16th a paper was read by Mr. H. G. Adams entitled "The Training of Boys and Youths in Engineering Duties." The subject was treated under the following headings:

(1) Recruitment for training;
(2) Education before training;
(3) Training; and
(4) Retention after training.

A course, accompanied by attendance at classes, was outlined, designed with a view to equipping the boy with a useful knowledge of the most important engineering work, and also providing a scheme whereby his services would be permanently retained by the Department and utilised to the fullest advantage.

An interesting discussion followed, in which Mr. A. S. Renshaw, of the Engineer-in-Chief's Office, who was visiting the District, took part.

D. BARRATT,
Secretary.

SOUTH LANCASHIRE CENTRE.

The sixth general meeting of the 1913–14 Session was held on March 2nd, 1914. The local Committee for the ensuing session was elected as follows:

Executive and 1st Class Engineers .	Mr. G. S. Wallace.
Assistant and 2nd „ „ .	,, G. Wildgoose.
Chief Inspectors and Sub-Engineers .	,, G. H. Vaughan.
Clerical Staff	,, F. Ashton.
Librarian	,, H. Willcock.
Secretary of Centre	,, W. B. Smith.

A paper on "Wireless Telegraphy" was read by Mr. G. C. Harris. The paper was illustrated by lantern slides, and a good discussion followed.

The first meeting of the 1914–15 Session was held on November 2nd. The Chairman, Mr. W. J. Medlyn, delivered his inaugural address. This was followed by a paper, read by Mr. A. Magnall, entitled "Notes from an Engineer's Pocket Book." A number of interesting lantern slides were shown, and a lively discussion followed.

The Committee of the Centre have been fortunate in securing a full programme for the present session.

NORTHERN DISTRICT CENTRE.

At the first meeting of the Session, Mr. F. G. C. Baldwin read a paper on "The Regulation of Plant Supply." The paper dealt with the provision of cable plant with special regard to the requirements of congested areas, and Mr. Baldwin may be congratulated on having made a somewhat difficult subject, from a lecturer's point of view, highly interesting and instructive. The lecturer's object was not merely to adduce an ideal scheme of cable distribution for each of the several classes of area considered under development schemes, but to suggest how the actual telephone growth of a district could be ascertained. The purpose of this would be to place on a scientific basis the means of ensuring that plant should not be allowed to remain in a non-revenue earning condition when it becomes fairly obvious that its eventual use has ceased to be probable, and also to make it possible accurately to observe at a glance where abnormal telephone expansion has occurred, thereby indicating the necessity for an increase of plant beyond the expected requirements. In effect, Mr. Baldwin's suggestions are the natural complement of a sound development study, and while admitting that the record system necessary to the working of the scheme would be somewhat elaborate, the lecturer contended that the cost would be but a very small fraction of the capital outlay on the plant controlled, and that a considerable advantage in economy and efficiency would accrue. The lecture was well illustrated by lantern slides showing diagrams of the various kinds of areas considered, and specimens of the proposed records. An interesting discussion, to which contributions were made by several members, followed.

Reference will be appropriate in these notes to the departure of Mr. Batchelor, our senior A.S.E., to the front. Mr. Batchelor proceeded direct to the headquarters of the Expeditionary Force, and is now attached to Sir John French's staff. The members of the Centre wish him good luck and every honour.

Yet another war item. The whole of the Northern Engineering District is pleased to note the mention of Corporal Scaife, one of our Skilled Workmen, Class II, in the Commander-in-Chief's despatch. The recipient of the distinction was recently home on furlough, and, under inquiry, modestly related that he was detailed in charge of four men to lay a line from the base to the trenches over an area under shell fire. The other men were reluctant to proceed; Scaife undertook the work alone, and succeeded in laying the line and delivering a despatch to the commander of the troops.

THE ETHICS OF SUPERVISION.*

By A. S. Renshaw.

The ethical principles governing the conduct of supervising officers differ in no essential from those governing the work of those whom they control, and for both of them the ethical standards governing their official life differ neither in degree nor in kind from those governing their private life as citizens. In practice we judge both supervisor and supervised by the contemporary standards by which we test the conduct of men in the ordinary walks of life; and there is something wrong if, in his official life, an officer drifts into habits and acts of which he would be ashamed in any other sphere. This common standard constitutes the basis of self-respect and mutual esteem. The ethics of supervision are therefore the ethics of the common life. The only justification for their treatment is that we habitually take them too much for granted to define them, or to consider their relation to the special facts of an official life.

(2) The obvious character of ethical principles is that they relate fundamentally to the personal relations between human beings for social ends. All communities are associations of men for the purpose of living well. Such association involved a more or less conscious basis of agreement to protect each others' rights in life and property and family. The effective enforcement of this primitive agreement added to the security and enlarged the boundaries of the individual life. But agreement involved subordination and restraint. From the primitive ethical core evolved a widening circle of obligations involving the individual in a network of prohibitions, precepts and maxims which gradually embraced every department of his life. Through ordeals and suffering and failure men perceived what forms of conduct were inimical to the general welfare, and it was but a short and natural step to forbid them and to build up a system of pains and penalties which it was the business of all properly constituted authority to enforce.

To give purpose to life men needed to know not only what they should *not* do, but what they *ought* to do. It was easier to crystallise the lessons of experience into a series of prohibitions, than to construct positive rules for future conduct, or to perceive the far-off ends to which the race was moving. Experience had taught what was wrong, but the absence of knowledge regarding ultimate social ends afforded no criteria as to what was right. Here and there at critical epochs came to men of more than ordinary insight the power to sum up in a living phrase the "Thou shalt not" of the law, and to envisage something of the higher destinies of the race. It is not enough that you should not rob, or kill, or steal. You may refrain from all these things and still fail to fulfil yourself as a man. In essence, these prohibitions mean that only by the active operation of goodwill among men is that kind of life possible which is worthy of intelligent social beings. So to the negative ethics of experience were added the positive ethics of illuminated insight. But even positive codes of ethics possess no finality. The goal of human endeavour is still very far off; and we can only safely rest on the principle that every ethical system is but a means to an end, that its value can only be judged in reference to that end, and that whilst we admit the validity of the racial authority with which these experimental standards are charged, we refuse to accept them as more than starting points for fresh processes of experience which may involve their complete supersession.

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* A summary of a paper read before the London Centre, Institution of Post Office Electrical Engineers, on October 19th, and the discussion that followed.

(3) But what men ought to do and what they do are very different things. Men differ in temperament, and an individual man may exhibit differences of attitude determined by a variety of apparently trivial circumstances. In respect of these touches of Nature we are all kin. A supervising officer needs the toleration and forbearance of his subordinates as often as they need his. Apart from accidental "ups and downs" human beings fall roughly into four groups:

(*a*) Men of reliant personality, in whom the ethical impulse operates spontaneously, returning to the endeavour again and again despite repeated failure.

(*b*) Those in whom the ethical impulse is less strong, but is fortified by prudential calculations as to the advantages of a measured minimum of conformity.

(*c*) Reflex flaccid types, who take their colour from their surroundings, and are good, or bad, or indifferent, according to changes of association.

(*d*) Individualistic types, which society must coerce to restrain their self-regarding and anti-social impulses.

To these must be added ungrown and immature types still in their formative years, who depend upon the constraints and influences which act upon them during growth, and for whom a large degree of social responsibility exists.

Men do not, in fact, fall into absolute categories of this kind. There are infinite degrees of gradation, and these characteristics meet and mingle in the same individual. Hence we do not legislate for men as types, but for specific acts. Society must defend itself against acts that impair its efficiency and frustrate its purpose, and sometimes must defend itself even against the good intentions of its friends in its endeavour to raise the general standard of life.

(4) The salient features of this brief sketch of the relation of ethics to the general scheme of things are no less familiar to us in relation to the proper subject of this paper than in the field of every-day experience. It is, indeed, not going beyond the warrant of the facts to say that, *mutatis mutandis*, as the pundits say—the necessary changes of terms being made—and departmental life is, in its general features, a microcosm of the whole scheme of things. We have bodies of men brought into association for certain preconceived ends. They are in agreement as to the ends to be achieved. By slow processes of experience and forethought certain principles have evolved, and certain precepts, maxims, prohibitions, with appropriate penalties, coalesced into a coherent code. The more effectively these things are enforced by constraint or suasion the more effectively are the preconceived ends which are our *raison d'être* accomplished. They involve subordination and restraint. In this smaller world it is not enough merely to refrain from doing this or that prohibited thing. Only by active and intelligent goodwill in every relation of departmental life is that life possible which is worthy of self-respecting men. Only by subordination of temperamental and personal differences to the general scheme is any reasonable degree of corporate success possible. And although the seat of authority is not in doubt, the principles by which it acts possess no sacred or final character, but are subject to endless change, extension, and supersession. They have to be judged by their consequences in breach or observance. The multitude of rules which sometimes perplex and annoy us in essence mean no more than that the service rendered should be efficient and honest service, that the personal relations among all grades of officers should rest on a basis of mutual respect and goodwill, and that what is morally wrong cannot be officially right.

(5) Although we can thus establish a rough and necessary identity between the departmental life and the larger social scheme of which it is an organic part, and therefore an identity of ethical obligation resting equally on supervisor and supervised, this contrasted relationship between individuals socially similar constitutes a special case in which filiations of a sensitive kind exercise far-reaching influences on both sides. Between the individual vested with authority and his subordinate lurks a potential antagonism varying in degree according to circumstances; hence, subject to a hundred qualifications, one might say that the narrower the margin of authority (other things being equal) the greater the inducement to reinforce it with suasions of a moral character; the wider the margin of authority the greater the likelihood of its being imperative or arbitrary, and therefore, in its misuse, hurtful to its possessor no less than its victim. Authority, even for good ends, like every other instrument, is capable of right use or *ab*-use—a means to an end and not an end in itself,

and fraught with good or bad consequences according to the way in which it is exercised.

It has been said that all authority is degrading, which is as if one should say that hunger is degrading because some men become gluttons, or thirst because some men become drunken. Whether authority degrades depends upon the manner in which it is exercised. In any case it is evident that the possession and exercise of authority involve ethical considerations of an important kind.

(6) The case in which there is high authority on one side and unquestioning obedience on the other involves a relation which is different both in degree and kind from that where the margin of authority is relatively narrow; and it is the normal relation between officers only one degree removed in rank from one another, in which authority must be reinforced and humanised by the force of personality, by ability and rectitude, by patience and good humour and tact, which is conceived to be the proper subject of this paper. In this region the considerations are more ethical and personal than authoritarian, and the interaction between officers so placed offers the most interesting and profitable field for investigating the ethics of supervision.

(7) The problem of supervision wears a variety of aspects, beneath which the problems to be solved present many common features. A specific task diversified as to detail is allotted, its general principles more or less broadly laid down beforehand. In practice this simple task has ramifications of a perplexing kind. The rules and principles have their seamy side. Selective examination on the cramming system has not robbed these splendid fellows set apart for the task of their full measure of humanity, which crops out in all sorts of ways and robs the paper formulæ of much of their deceptive completeness. It is nothing less than an average sample of human nature—instinct with sub-conscious revolt against the monotony of treadmill tasks and sedentary confinement. Some can be relied on absolutely; some must be watched; some need the judicious stimulation of prudential considerations; some, ungrown, need training in good official habits and help in the unfolding of personal character. We cannot rid ourselves of responsibility for the impress upon growing types of the environment we create for them. The *personnel* thus presents degrees of ability and idiosyncrasy. This man has an aptitude for constructive method; that man has a keen analytical faculty; this man is willing to accept responsibility; that man is timid and hesitating; this man is slow, but safe; that man is quick, but erratic; this man is diligent; that man a dreamer with a rare capacity for forgetting the world, or he may be lazy, or of the cynical type which measures work as you measure gas—so many cubic feet per shilling. . . . Every man is a type, and the most interesting

problem is to assess the type and fit him to the task suiting his aptitudes, and at the same time to avoid stagnation, which is damnation. These personal considerations are not irrelevant. The best designed organisation is no better than the human material of its working staff, and it is the concern of wise administration to put each man where his faculty will give the best result to the organisation and to the man himself, and to avoid the too close association of incompatible types, without laying too much emphasis upon questions of form so long as the thing aimed at is done promptly and well. To perceive the use to which a man's bad, no less than his good, qualities can be put is an aspect of genius. And when sometimes we find ourselves depressed by the man who finds a sort of inverted pleasure in growling all round the clock, who growls because there is a draught, or because there is not a draught, or because things have become so flat that there is nothing left to growl about at all, it is well to remember that even the most inveterate growler has his lucid moments, during which he forgets his morbid vocation in the unconscious gladness of being alive.

(8) A reference to the supervisor is not irrelevant. Although we dub him a "superior officer," we do not suppose that he is *ipso facto* a superior person. He has been put into the higher position for a specific and well understood purpose, one of his functions being to provide the appropriate stimulus to those who lack the voluntary ethical impulse. Where the ethical impulse is spontaneous, authority operates less and less, and a virtual equality of moral and intellectual fellowship makes itself felt.

In addition to executive ability a supervisor should be a fair judge of character, and of such personality as ultimately to secure an acknowledged ascendancy over his subordinates. He must get the allotted task done in the best way in the shortest time. Efficiency is judged by the quality of the service rendered and the cost of rendering it. Instructions given must be clear; weak places must be discovered. The "team" should realise that sense of solidarity which secures effective combination. A broad view of responsibility must be created. Where the work of one group is dependent upon another group the aim should be to deal with that portion in the best way at the right time. The supervisor must win the confidence of his subordinates in the fulness of his knowledge of the work in hand, and not act merely as a "funnel" between his subordinates and his superior; his official conduct should be such as he would not be ashamed to see reflected in his subordinates. Where frequent failure to achieve a promised result occurs, bad luck is often a synonym for bad management.

(9) A supervisor is essentially a trustee—a point which has interesting implications. We carry our care to prevent the leakage

of stores to such lengths that sometimes we spend more money on the machinery of prevention than the cash value of our risks. In a staff of sixty persons an average loss of fifteen minutes per head each day would at the low average of £2 a week amount to £104 a year. The responsibility for such loss is quite as real as for the loss of an equal amount of official cash. In one sense the department has bought so many hours of each man's day, and is as much entitled to "full weight" as if it were buying butter. Hence all methods of supervision must be directed to the full employment of each man's time. To this end all possible time-saving devices must be employed: shorthand writers, typewriters, adding machines, slide rules, ready reckoners, duplicators, telephones, filing and indexing contrivances, card systems and the like. The same considerations bear upon the routine methods employed, all possible labour-saving subdivisions being utilised. Instead of duplicate checks on small details we must employ broad checks on large results. The principle has come into operation of "one preparation and one check." A sense of the cash value of time has turned our minds from too anxious regard for nails and sixpences, and averages of a reliable kind have come into use. A change of heart has taken place. From being nervously *arithmetical* our methods are becoming severely *statistical*. Equally good results are obtained, a larger volume of work is handled in a shorter time, and we are gaining courage.

(10) The mass of regulations confronting us sometimes seem to have been invented for the sheer fun of the thing, and the illusion that they are superadded to the general ethical principles of everyday life becomes oppressive until we realise that they are only particular applications of the same things; that common-sense, good judgment, and goodwill cover most of the ground; that after a brief experience we only need to turn to them in special cases; that they are only a means to an end and not an end in themselves, and are only oppressive to those who break them. This multitude of rules frees us from the conflict of personal and immature judgments. They are largely reducible to simple and intelligible principles. When they cease to bear this character they should be broken and put away. It is the function of experience and reflection to discover in their underlying principles clues to the solution of problems which no ingenuity of foresight could provide for beforehand.

(11) Rules and prohibitions, such as they are, apply with equal force all round. It makes a vital difference in the loyalty with which they are observed by subordinates if it is seen that their incidence is the same for all ranks. Thus no officer, however high his rank, has other or greater rights to the use of official cash or material for private purposes than the lowest officers. This illuminating principle makes the same demand on each individual, and is a test

by which a reasonable judgment can be formed in otherwise doubtful cases; whatever practice would be open to condemnation if it became universal is inexpedient in individuals.

(12) The question ultimately resolves itself into the cost of doing this or that thing. If the best organisation is no better than its human material the best human material is ineffective with bad organisation and inefficient direction. Good organisation is therefore the key of efficiency, and efficiency at the bottom is a question of cost. To be effective men must act together. To act together there must be a common object, a common understanding, a common method. Each man must have his defined task, and sub-division must preserve organic unity. These sub-divisions will be reasonably permanent in character, though they in turn have no sacred or final character. They have to be judged solely by results, and to run the gauntlet of endless criticism. To regard any form as final is to close the door to improvement and to stultify the will.

(13) The co-ordination of related sections of work is of supreme importance. Unless a common standard is aimed at, miscarriage may be looked for with the certainty of a natural law. In nothing is the quality of supervision shown more than in achieving this unity of achievement, and in preserving in the minds of a large number of men the sense of a common task.

There are many militating influences, but when everything has been said the problem of supervision is first and last an ethical one, which can only be solved by reference to those ethical principles which are the staple of good living in any walk of life.

DISCUSSION.

The CHAIRMAN (Mr. PURVES) said: I hoped to be able to call upon the Engineer-in-Chief to open the discussion, but in a letter I have before me he expresses his great regret at being unable to attend this evening's lecture. At the same time he trusts it will be a successful one. I think I must let Mr. Slingo know that in thus withholding from us his views on the ethics of supervision he has disappointed a good deal of somewhat wistful curiosity on the part of his staff! In his absence I have much pleasure in calling upon Mr. Stubbs.

Mr. STUBBS said: Mr. Chairman, Ladies and Gentlemen,—Those who know Mr. Renshaw will have assumed that he would treat this matter with the thoroughness that characterises all the work he does, and I am sure that in this respect he has not disappointed us. In reading the paper I was impressed with the feeling that Mr. Renshaw must himself from time to time have been a little doubtful as to the sufficiency of his title. There seems to be so much "ethics" about it and so little "supervision." He gets about half way through the paper, for instance, before he has occasion to distinguish between the supervisor and the supervised, and I think he gets to about page 7 out of his eleven pages before suggesting that a reference to the supervisor himself will not be irrelevant. It seems to me he might borrow a phrase from his paper to expand the title and call it "The Ethics of Supervision, or *mutatis mutandis*, as the pundits say."

In section 2 of his paper this passage occurs: "But even positive codes of ethics possess no finality—the goal of human endeavour is still very far off: and without attempting to touch the tangled question as to the ultimate seat of authority in ethics, we can only safely rest on the principle that every ethical system is but a means to an end, that its value can only be judged in reference to that end, and that whilst we admit the validity of the racial authority with which these experiential standards are charged, we refuse to accept them as more than starting points for fresh processes of experience, which may, as knowledge grows, involve their complete supersession." Now I venture to say that nothing in the paper suggests that Mr. Renshaw is at all disposed to sympathy with the ethics of that type of culture with which the Germans have endeavoured to enrich the world, but in spite of that consideration I am still constrained to join issue with Mr. Renshaw on that statement. I suggest that the text from which he has preached to us is not an "experiential standard charged with racial authority"; it is the immutable law of God Himself formulated for us 1,900 years ago by the very highest personal, and not mere racial authority, when He issued the command, "Do unto others as ye would that they should do unto you." It is, indeed, a "starting point," but it is more: it is a goal; and if, as knowledge grows and by fresh processes of experience, this goal is overpassed, the supersession will be, not the progress, but the downfall of the race.

I quite recognise the correctness of the admission that not four nor four hundred different categories will enable us to classify the human race. In fact it did strike me that perhaps, when the craze for limericks and football competitions and bullets has passed, some intellectual paper—'John Bull' perhaps—might introduce a competition for a definition of four classes into which the human race can be properly divided.

One of the most remarkable passages in this paper appears to me to be in Section 5: "But no less interesting, if we could effect it, would be a contrast between (let us say) the mental attitude of the inspector and the mental attitude of the engineer in relation to the same workman. One might say broadly (subject to a hundred qualifications) that . . . the wider the margin of authority the greater the likelihood of its being imperative or even arbitrary, and therefore . . . hurtful to its possessor no less than to its victim." Let us take as an example the "margin" which separates the Postmaster-General from the skilled workman. Can it be contemplated that there is any likelihood of the Postmaster-General being harsher or more arbitrary in his treatment of a workman than an Inspector would be?

The author deals very prettily, in Section 7, with some aspects of the problems of supervision. His review suggests that, like a certain policeman, the supervisor's lot is not a happy one! Mr. Renshaw may be interested to know that I have known an exception to his rule that "even the most inveterate growler has his lucid moments." On my brother's staff at the Board of Education a man returned from what was admittedly a glorious holiday, and his verdict was that it was "rotten." What was the explanation? Well, for the whole month he had been thinking that after all he would have to "go back to the beastly office"!

When I think of the amount of correspondence, etc., that is involved before a new form of office utility—say a rubber stamp—is sanctioned, I fancy that Mr. Renshaw's list of shorthand writers and typists, typewriters, adding machines, slide rules, ready reckoners, duplicators, telephones and the like, even if not supplied as indulgences or toys, must seem to the ordinary chief clerk a phantasm of the brain or a dream of paradise!

Section 9 at the end says that, whatever the ethical conditions may be, our present statistical conditions are a good deal in advance of the previous conditions. I believe that Mr. Renshaw may be given some appreciable part of the credit for obtaining this result.

Section 10 affords another instance of the wonderful opportunities Mr. Renshaw has. Is there another man in the Engineering Department who has ever heard a complaint that our regulations and instructions are not numerous enough?

Mr. NEWLANDS, Controller of the Central Telegraph Office, said: Mr. Chairman, Ladies and Gentlemen,—I think your Society is to be congratulated on the fact that it enables papers to be prepared such as this one to-night, which does not deal with a merely technical subject. I believe thoroughly in the assumption that if Mr. Renshaw had delivered a technical address to-night the number of the members present would have been trebled. I think the subject which Mr. Renshaw has taken a far more difficult one than the ordinary technical one. In fact I venture to say there are scores of people connected with the Engineering Department who would far rather express their views on a technical subject than on the subject before us to-night. I do not want to criticise the paper. When I read it I felt that it so fully expressed a great many of the ideas which appealed to me that anything that I could say would rather be supplementary than condemnatory. The paper to me is brimful of wisdom and common-sense. It is clearly stated, and there are numerous fine passages in it. In my opinion it deserves a wide perusal and close study by all officers.

Mr. Renshaw does not wish us to imagine that a higher standard of personal conduct is demanded of officers of supervisory rank than from the general body of the Staff. In my judgment officers may be divided into two classes: those who, whatever their rank may be to begin with, inherently possess the higher ethical standard, and those who don't. Only those officers who really possess the higher ethical standard ingrained in their personal character are fully qualified to exercise supervision over their fellows: all others have been weighed in the balance and found wanting. It may be that much of our general equipment and capacity is inborn in us; that heredity, home influences, physical fitness, and general education count for much, but I firmly believe that on entering the Service we are all far nearer equality than we suppose. As a rule it is a fair field and very little favour. Everything depends upon the individual as to whether he will aim steadily at self-improvement, with a view to ultimate efficiency and advancement, or whether he elects to take it easy and hopes that "something will turn up." We are constantly making our own standards, and others around us can read our characters like a book from the standards we set in our daily life.

There is, as Mr. Renshaw says, something wrong somewhere when a man in his official life allows himself to drift into habits and acts of which he would be ashamed in another sphere. The wrong is in himself, and ultimately he pays the inevitable penalty without a doubt. In my experience of men and women the ethical standard is so high that a very large percentage require very little close supervision; the balance, the other percentage, stand in need of all the supervision that can be given them, and this is entirely due to their own personal low standard. There is one subtle fallacy which constantly crops up, especially in all Government services, namely, the suggestion that thoroughly efficient service is almost entirely due to the amount of emolument paid. This is incorrect. I have known men at 20s., 25s., 30s., 35s. a week, and all the fives and multiples of five, who all their lives gave the very best of their service and who could not have given more if you had doubled, trebled, or quadrupled their salary. The man who does his very best and who has the capacity to do well naturally deserves the reward and gets the reward.

That portion of the paper headed: "The Problems of Supervision" calls for close scrutiny and careful study. He says it is as important to prevent loss or wastage of time as it is to prevent the loss of copper wire, and it is the first task of supervision to prevent such loss. This is refreshing, and may come to some with all the force of a new revelation.

In my opinion this paper will greatly benefit those who read, mark, learn, and inwardly digest its contents.

Mr. MANSBRIDGE said: Mr. Chairman,—I have only one quarrel to make with this paper. The point upon which I disagree occurs in section 5, where it is suggested that "between the individual vested with authority, and the individual vested, so to speak, with subordination, there is a subtle but instinctive antagonism, varying in degree according to circumstances." Now, making all allowances, that may perhaps be correct, but I am bound to say that in my experience men, as men, *like* to be controlled. Now, if this is so, if they like to be controlled, I cannot see where the antagonism necessarily lies. Men, of course, like to be controlled by a good man.

In regard to various other points, the whole thing, as Mr. Stubbs said, may be crystallised into a very few words when you come to deal with the ethics of supervision. I jotted down a little note. It is, "Do as you would be done by." It is not very far off Mr. Stubbs' more accurate quotation. I was rather interested to note at one place—section 8—a reference to officers who simply act as "funnels"; the more or less tacit admission that they exist in sufficient numbers to call for comment, struck me as a little bit curious. Again, there was a point made by Mr. Stubbs as to the paper covering more than merely the ethics of supervision—a very restricted field of ethics. Had the paper been on supervision generally, no doubt the field would have been much widened and we could have said more. The most important point in supervision is, in my experience, in the early days when we are training the youngsters of the staff. I won't say that *anyone* can supervise a shop—I am speaking largely from factory experience rather than from the different kind of experience which, I think, most of the members of this Society are accustomed to—I would not say that *anyone* can supervise a shop of high-grade men, but I would say that it is far easier to supervise well a shop of high-class mechanics than one comprised of lower-grade men, and particularly there is no shop so hard to supervise as one made up almost entirely of youngsters. Not only do they require more supervision on account of their tendency to go in wrong directions, and to do wrong things in their work, but they have a much greater tendency to go wrong as regards their conduct and so forth.

As regards the character of the supervision, there are various references to that, but the point that struck me in reading this paper was the reference to that supervision which produces good results under different circumstances. I have seen in French and Italian workshops men, thoroughly good men, working hard and working well, and smoking cigarettes the whole of the time. Now, in these shops such an action is thought nothing of, and good discipline, good control is exercised and maintained in these shops under such circumstances. Obviously one could hardly expect good control in English shops under similar conditions, but I am bound to say that in some of these shops I know the control to be every bit as good as it is in others, the locality of which I need not name, but which will be sufficiently indicated when I say that they are placarded with the various things that are "verboten." You have, therefore, good control, good supervision in the English, French, Italian and other shops under totally different conditions. So that if you make your conditions to suit your men and women you can get effective control, provided you get the supervisors to understand the conditions and to understand and know the men.

In thanking the author for his very interesting paper, I should like also to thank him for an introduction to quite a few new words!

Mr. ATKINSON said: Mr. Chairman, Ladies and Gentlemen,—I feel that first of all I should like to thank Mr. Renshaw heartily for what, to me, has been a very interesting paper. I think I can say with truth that I concur in all the felicitous expressions that have already been voiced by the previous speakers. The paper is one that has certainly caused me to think—I don't mean to say that I have not thought previously on the subject of supervision—but it has presented so clearly the problem confronting the supervisor that I can truthfully say I have not fully appreciated the problem before. Mr. Renshaw is perfectly right in putting in the forefront of his paper—on p. 1—this passage: "Nor are we conscious in passing from our official to our private life of any ethical adjustments taking place, or of any ethical opposition between the two. There are, of course, affectional and emotional changes, otherwise we might not, perhaps, desire to go home; but there is something wrong somewhere if a man in his official life allows himself to drift into habits and acts of which he would be ashamed in any other sphere. Indeed, it is this similarity of standard for both classes of officers, and for both aspects of our common life, which constitutes the basis of self-respect and mutual esteem." Now, that seems to me to sum up the position which should be occupied in official matters, and it needs no qualification. We should not feel it necessary either in coming on or going off duty to readjust ourselves to the position we have to face. No one in a supervisory position should feel himself differently placed from the position he would occupy as the head of a family; that is to say, it should be very, very seldom indeed that the rebuke should be harsher than that which would be administered by a parent to a child. There are occasions, of course, when a rebuke from a parent to a child must be accompanied by harsh measures, occasionally, indeed, by corporal punishment, and I do not mind saying that some of our youngsters in official life would be much the better for a little corporal punishment sometimes. However, I think we can say that in the Post Office, taking into consideration the size of the staff, it is very, very seldom that serious disciplinary cases arise.

I am rather inclined to think that perhaps some of us who occupy positions of authority get into those positions and assume that everything is met by rank and the increased pay which we have been looking forward to, but it is not quite enough to take refuge behind the old saying that "A good servant makes a good master." I think that, as the State should be a model employer, so every employee in a State department should endeavour to be a model employee, and that where supervising functions have to be exercised the weakness, as well as the strong points, of our subordinates ought to be very, very carefully considered.

In dealing with this question of supervision it is not easy to draw the line between supervision and organisation. It seems to me that one difficulty which all supervising officers have to contend with, and to which Mr. Renshaw has alluded, is the tendency to assume that in other departments the staff is more than ample for the work, and that, in addition, "they don't know what they are doing." The offenders require, of course, to be educated to state their views a little more moderately. The vast organisation of the Post Office makes it very difficult to put forward suggestions having reference to another department without implying that that department has been lax in its own administration, and yet in the very nature of things each department sees, as it thinks, flaws in the methods and general organisation of the others.

There is one other point which Mr. Renshaw has touched upon. On page 10 we have this passage: "It is significant that, whatever aspect of this question we discuss, it sooner or later resolves itself into a problem as to how the *time* of the working staff can be most effectively and economically employed—*i. e.* at the bottom the cost of doing this or that thing." I think that brings in another great difficulty which the supervisor, as distinct from the supervised, has to face. He has to distinguish between the things which should be ignored and those which have an important bearing on the general working of the machine. It is not an easy matter, because frequently a trivial matter is associated with a big multiplier and the aggregate gain or loss involved is very considerable.

Mr. NOBLE said: I understood you were to have the Engineer-in-Chief here to-night to open the discussion. Mr. Stubbs has acted as a very good substitute, and I thought you were going to let me off. First of all I would like to congratulate Mr. Purves on the position which he now occupies. I hope he will preside at successful meetings throughout the Session. Mr. Atkinson caused a good deal of amusement in his reference to corporal punishment and he spoke as if it was a thing unheard of in the Post Office Service. As a matter of fact I have seen it in operation during my own service. There was a superintendent in the telegraph office at which I began work who used to use G.P. wire for chastising boys, and after he had done it he would say: "Now you go and stand up in that corner for an hour." Yet I have never in all my experience come across another supervising officer like that man in his treatment of his staff. As an example of how he behaved I might mention an incident that occurred when I was on night duty from 10 p.m. to 6 a.m. Between three and six nobody was in the office but myself. The First News started to call up about 5 o'clock and I didn't hear it. The Second News, Edinburgh, and then Glasgow, then Dundee, but I didn't hear them. I had to explain what happened, so I told the superintendent that I had gone to sleep. He told me "To tell the truth and shame the De'il." I did so and got a simple reprimand. A month or two later another officer did the same thing. He was treated in a very different manner. He said all the wires must have been faulty. The reason why I got off so lightly was because I had told the truth about the matter. If you get a supervising officer like that one, who differentiates between right and wrong, then you have an officer who, provided he does his other work thoroughly, is an acquisition to the State. I would like to congratulate Mr. Renshaw on his paper. I will not say that I agree with all he says, but I think the paper as a literary effort is admirable. Leaving out the reference to paybills, stores summaries and so on, it might have been read before the Oxford Debating Society. Whilst admiring the paper as a literary effort it is not quite the style for an engineering society. I like short sentences and Anglo-Saxon words. Mr. Renshaw adopts the Gladstonian style; I believe in John Bright's style. Instead of criticising the paper I thought I would just jot down one or two qualifications that I thought a supervising officer ought to have and what his conduct ought to be. I think he ought to have initiative, executive ability, organising ability, and a full knowledge of his own weaknesses as well as his own strength. Mr. Renshaw told us he ought to know his men; he should also know himself. To my mind it is most important that a supervisor should know his men thoroughly; know where they are strong and where they are weak, and then arrange the men according to their ability. There is too little attention paid to this sorting out of men. Supposing there are three vacancies in a superintending engineer's office, one each, say, in the accounts, technical, and wayleave sections. I have seen this done: Here is Mr. A, we will put him into the accounts section, B will be sent to the technical section, and C into the wayleave section. This, notwithstanding the fact that A holds numerous technical certificates and has no liking for figures; that B has a strong partiality for legal matters and would therefore be more useful on wayleaves; and that C has an aptitude for accounts. It is the duty of a supervising officer to see that each man is fitted into his proper sphere—where his labour gives the best results. In this connection I remember many years ago being asked if I knew of any men who would be willing to come to London. I named two men and shortly afterwards they came. I asked where A was going and was told "the wayleave section." I said "his time will be wasted. He will do the work well, but his services would be more valuable in the technical section." The change was made with the result that A has been a tower of strength in the Engineer-in-Chief's office. A supervising officer should set his men a good example in everything. He cannot expect punctuality from subordinates if he is unpunctual himself, and he cannot complain when they don't work hard if he doesn't work hard himself. There have been administrators who have considered that a man should be fit to fill any position, but my opinion is that you cannot fit round pegs into square holes; few men have the ability to fill any position in a complex administration; and men should be selected for positions according to their bent and qualifications.

Mr. GUNTON said: Mr. Chairman,—Mr. Renshaw's paper is as difficult to criticise as the sermons which we hear from our Vicar on Sunday, but I think it will do us a great deal of good. I think some high and mighty persons on the continent of Europe would be all the better for reading Section 2 referring to right and wrong, to which Mr. Stubbs has responded.

There are many aspects and ramifications in Mr. Renshaw's paper, and many things that a supervising officer should do and should not do. There is one ramification, however, which has not so far been dealt with; that is the relation between the supervising officer and the contractor. I think that relation comes quite clearly under the heading of "The Ethics of Supervision." Take the case where an officer is confronted with a request from a contractor for payment above the estimated cost owing to unforeseen developments having arisen. The contractor's request may be perfectly reasonable and fair, but still, according to the exact wording of the specification, he is not entitled to any extra payment. To make a recommendation in a fair way to both sides in a case like that requires moral courage. It is the duty of an engineer certainly to see that work is promptly and properly executed, but I think it is also his duty to see that a contractor gets fair play, and an officer should not be influenced in his differentiation of right and wrong by the fact that he has behind him a large weight of authority.

I was glad to see Mr. Renshaw's references to the grumbler and growler. We have recently had a very good example of how superficial grumbling may be. Even Tommy Atkins when he is in clover occasionally indulges in grumbling. We have recently seen what Tommy Atkins does when he is *not* in clover. Altogether I think Mr. Renshaw has set a very high standard and a very good precedent, and I hope that when papers dealing with the moral aspects of official life are announced in future, Mr. Newlands will not be able to point to small audiences.

Mr. Moir said: Mr. Chairman, Ladies, and Gentlemen,—I should like to compliment Mr. Renshaw upon having achieved success in a task which I thought was more or less impossible. The science of ethics has always been regarded as a very abstract subject, and to bring it up against anything so commonplace as the routine of a superintending engineer's office seemed to me something very difficult.

You all know, of course, that the science of ethics was founded by Socrates, and that Plato and Aristotle took a hand in its development. In all ages it has attracted the attention of the great masters of thought, and to come down from the heights occupied by such men into the valleys in which we live, and to apply ethical considerations to the section stock and the stores summary, etc., was really a risky undertaking, but I am prepared to agree that Mr. Renshaw has been more successful than I anticipated.

If any supervising officer came here with a good conceit of himself and imagined there was something of the super-man about him, Mr. Renshaw at once made it clear that he was labouring under a great delusion. In Section 8 he refers to the supervising officer in this manner: "And perhaps a word about the supervising officer himself may not be irrelevant. Although we sometimes dub him a 'superior officer,' we do not suppose that he is *ipso facto* a superior person." It is quite right that that should be fully understood.

I was greatly interested in the four groups (Section 3) into which human beings can be divided, but when I tried to fit some of the supervising officers I know into one or other of these classes I failed, and I thought here now I am going to get up against Mr. Renshaw. But with the elusiveness of the true ethical propounder, he puts in a saving clause at the bottom of his specifications which runs thus: "It would, of course, be a mistake to suppose that individuals can in fact be graded into absolute categories of this kind." Well, he is on perfectly safe ground there.

I must say I believe very fully in that part of Mr. Renshaw's paper which deals with the relationship between the supervisor and the supervised, and also, of course, in his reference to economics and efficiency. Mr. Renshaw's paper has been to me a very interesting one.

At this point the CHAIRMAN proposed a vote of thanks to Mr. Renshaw, which was heartily responded to.

Mr. RENSHAW, in reply, said: Ladies and Gentlemen,—Like Mr. Noble I do not like long sentences, and it appears that this is my opportunity. My sentence is a very short one, and as I have only three-quarters of a minute it is almost unnecessary to say anything at all. But there are one or two things that perhaps might be said even if we overrun the painter—this clock is, I think, a little fast. Some stress seemed to have been laid on the fact that in a paper dealing with the ethics of supervision, I spoke about *ethics* instead of *supervision.* I was entitled to divide the audience into two parts—those who supervise and those who are supervised—and I desired to show that in both capacities the same ethical considerations apply. It was inevitable in order to establish some identity between the little official world in which we live and the larger world of which we are members, that I should endeavour to develop, what might be called, the historical side of the subject—the development of ethics. It is very unfortunate that in attempting to do that I should have Mr. Stubbs in a position that seems like hopeless antagonism. He seems to suggest that if ethics, as I understand them, were superseded, we should bring the whole thing to chaos and wreck. Because, he says, ethics are not experiential at all, they are authoritarian, and they commenced 1,900 years ago. But Mr. Moir helped me out of this difficulty. He said that five or eight centuries before that time certain persons, whom I need not name, set themselves to consider the question of the relations of ethics to life. I still maintain that the ethics which relate to the common life of men and women in their relation to one another among material things and material conditions have been drawn entirely from experience, and that the only test that we can apply to any particular conduct, whatever it may be and wherever it is, is: "Does it hurt or does it help the body politic, the body social or the body official, as the case may be?" With such a simple test as that it is not difficult, as a rule, to resolve some of the more difficult problems that arise.

The next point leads me to suppose that there is perhaps some misconception as to what I really meant to say. I said that the narrower the margin of authority between persons, the more inducement there will be to reinforce it by suasions of an ethical and personal character. Let me illustrate the case I had in mind. If you are supervising a body of men of your own age, of your own training, and your own social standing, you face this difficulty in a very acute form. Here is a man who had done badly something you might reasonably have expected him to do well, and in plain English you would like to tell him that he is a blockhead. But you cannot help remembering that he is the father of a family; that at his church he is a deacon; that probably in the ordinary walks of social life he is a better man than you are. Instead of speaking to him in a rough or authoritarian way, you try to speak to him as an equal, and if you do this—if you speak to him as one man to another in a friendly way—I think you are not only likely to arrive at the end you seek without causing any estrangement between him and you in the future, but that the encounter will have done both the supervisor and the supervised good. When one is dealing with people who are very close to oneself in rank, it is more and more difficult to rely upon one's authority and more and more necessary to rely upon tact and goodwill and courtesy and to preserve the feeling of fair and equal dealing.

Mr. Mansbridge, in some very kind remarks, observed that he attached enormous importance to the responsibility resting upon supervising officers when they have young people to deal with, and I am with him there all the way. I think that the supervisor should pay great attention to the ungrown and adolescents in his charge, not merely training them in their official duties, but training them in the qualities that will strengthen their manhood.

It was said that I had left out something that was most important, namely, that the supervisor should know his men well. I did say that one of the chief duties of administration was to put each man where his labour gave the best result, and to avoid the commingling of incompatible types. There are many things one could add to this discussion, which has been much more helpful and much more lively than I thought it would have been, but we have reached our time limit.

POWER CIRCUIT INTERFERENCE WITH TELEGRAPHS AND TELEPHONES.

THE third meeting of the 1914–15 Session of the London Centre, I.P.O.E.E., was held at the Institution of Electrical Engineers on the 21st ult., when a paper with the above title was read by Mr. S. C. Bartholomew.

The writer dealt separately with the three different types of commercial power circuits—electric light and power systems, electric tramways, electric railways—and sub-divided his paper into two parts, viz. (*a*) how the "lay-out" of the power system interfered with telegraph and telephone circuits, and (*b*) the steps which may be taken to minimise these effects.

Interference may be caused either by leakage or by induction, or a combination of both. Leakage refers to stray currents which leak on to the earth connections of a circuit and flow through the wires. Induction may be either electro-magnetic, which varies with the current, or electro-static, which is independent of the current and is a maximum when the load on the power circuit is *nil*, that is to say, when the circuit is open. Both vary with the frequency of the supply.

Mr. Bartholomew gave a description of the effects produced on communication circuits by the presence of disturbing power circuits, and explained the attempts that have been made to eliminate them. All the methods so far applied to Departmental circuits are but palliatives only, and the solution of the difficulty is to be found in the lay out and method of working the railways. The installation of a single-phase railway in the neighbourhood of main telephone lines with the simple lay-out of the alternator feeding the trolley wire direct or through a step-up transformer must be regarded as an unfriendly act on the part of the railway authorities.

The discussion was taken part in by Messrs. A. B. Trotter, of the Board of Trade, J. G. Hill, H. C. Gunton, and S. A. Pollock. Mr. Trotter pointed out that the Board of Trade must take up a diplomatic attitude of neutrality, and said the fact that no Committee had inquired into the subject since 1893 appeared to indicate that, so far as this country was concerned, the trouble had not been serious.

BOOK REVIEWS.

'Wireless Telegraphy: a Handbook of the Fundamental Principles and Modern Practice of Radio-telegraphy,' by A. B. Rolfe-Martin, B.Sc. (Adam & Charles Black. Price 5s.)

The author has written this book for the use of the average student of electrical engineering, and has endeavoured to give the broad principles upon which the science of wireless telegraphy is based without going into much detail. The book is written in a clear simple style, and no attempt has been made to give a mathematical treatment of the subject. It is surprising, therefore, to find that no attempt has been made to help the reader by means of mechanical analogies. The subject matter is principally confined to the Marconi and Telefunken systems, and there is little detailed information as to the production of continuous or undamped waves, and the different devices used for detecting them. The methods of making high-frequency measurements of capacity and inductance are not given, the considerations that determine the site of a station and the different laws that govern the transmission of electromagnetic waves are not touched upon, and the latest means of magnifying and relaying receivable signals and the possibilities of high-speed working are not mentioned. The above are but a few examples indicating that much would have to be added before the book could be considered complete. In short, the book does not cover sufficient ground or give enough detail for the student of wireless, but it gives in simple language the broad principles of the subject to those who do not wish to specialise in it.

'Elementary Principles of Wireless Telegraphy,' by R. D. Bangay. (Marconi Press Agency. Price 1s.)

This should prove a useful little work, with a great deal of information packed in a small space. The attempt to cover, in a very limited compass, the whole field of magnetism, electro-statics and dynamics, chemical action, units and laws, is scarcely to be commended, but in the present case it is done as well as is fairly possible in such circumstances.

In dealing with the heart of the subject—which is confined to the "spark" method—the author's plan is lacking in a clear presentment of the whole. The different parts, aërials, receivers, wavemeters, etc., are well described, but they do not "fit in" or form an easily-comprehended whole. For a work dealing with the elements of the subject, a clear outline of the matter as a whole appears to us to be necessary; the parts then take their place naturally. Otherwise the work is well done, the analogies clear and helpful, and the book full of information.

'Questions and Solutions in Telegraphy and Telephony,' Fourth Edition, by H. P. Few. (S. Rentell & Co., Ltd. Price 2s. 6*d*. net.)

In his fourth edition Mr. Few has included the City and Guilds examinations from 1912 to 1914, and the Departmental examination papers for Overseers and Assistant Superintendents. He also gives a list of forty-eight practical and oral questions which have been actually asked by the examiner. These should be very useful to candidates, as they give a better indication of the scope of the examination than is afforded by the published syllabus.

ROLL OF HONOUR.

We sincerely regret to announce the deaths of the following men killed in action, who were drawn from our Department for active service. (N) Navy. (A) Army.

Name.	Class.	District.
G. F. Adams (N)	Skilled Workman, unest.	S.E.
G. J. Barton (N)	,, ,, ,,	,,
A. Beard (A)	Labourer	,,
P. Benford (Marines)	Skilled Workman, unest.	London
R. H. Boyle (A)	Labourer	,,
F. A. Bremer (N)	Skilled Workman, Cl. II.	,,
E. Bridges (A)	,, ,, unest.	E.
C. Chapman (N)	Labourer	London
F. W. Chapman (N)	,,	,,
A. Clayton (A)	Skilled Workman, unest.	S. Mid.
W. Cobb (N)	,, ,, ,,	S.W.
E. E. Cook (A)	,, ,, ,,	London
W. H. Cousins (A)	,, ,, ,,	N.E.
J. R. Davies (N)	,, ,, ,,	S. Lancs.
J. Donnelly (A)	Labourer	Ireland
W. Eggar (A)	Skilled Workman, unest.	S. Mid.
D. Eyles (A)	Labourer	N. Wa.
E. Ezard (A)	Skilled Workman, unest.	S.W.
W. G. Gardner (A)	Labourer	London
H. J. Guymer (A)	Skilled Workman, unest.	,,
H. Harmer (A)	Jr. Cl. Assist., ,,	N.W.
W. H. Harris (N)	Skilled Workman, ,,	S.E.
C. B. Harrison (N)	,, ,, ,,	N. Wa.
F. Hills (N)	,, ,, ,,	S.E.
F. Hogg (A)	Labourer	S. Wa.
G. Hollingsworth (N)	,,	N. Mid.
A. Hooker (N)	,,	E.
F. Johnson (A)	Skilled Workman	N.E.
A. D. Kerr (N)	Labourer	London
W. Matthews (A)	,,	N. Wa.
W. McCann (A)	Skilled Workman, unest.	Scot. E.
C. Munday (A)	Labourer	S. Mid.
J. A. Munro (A)	,,	Scot. E.
H. J. M. Nicholas (A)	Skilled Workman, Cl. II.	London
R. Norman (N)	,, ,, unest.	S. Wa.
J. Pringle (A)	Labourer	N.
A. E. Prowse (A)	,,	S.W.

Name.	Class.	District.
J. Rayner (A)	Labourer	London
H. Robinson (A)	Skilled Workman, unest.	S. Mid.
J. W. Sharp (N)	,, ,, ,,	London
H. A. Stevens (A)	Youth	S.W.
W. T. Tarrant (N)	Liftman	London

The list has been extracted from the Post Office Circulars, and is complete up to and including the issue of December 15th.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From.	To.	Date.
Gibbins, F. E.	Exec. Engr., N. Wa. Dist.	Asst. Supt. Engr., N. Eastern Dist.	1 : 1 : 15
Partridge, T. T.	Asst. Engr., E. in C.O.	Exec. Engr., N. Mid. Dist.	20 : 9 : 14
Field, A. W.	Engr., 2nd Cl., N.W. Dist.	Asst. Engr., N. W. Dist.	1 : 8 : 14
Day, W.	Engr., 2nd Cl., E. in C.O.	Asst. Engr., E. in C.O.	11 : 8 : 14
Osborn, W. M.	Engr., 2nd Cl., East Dist.	Asst. Engr., E. in C.O.	4 : 10 : 14
Grocott, J. R.	Chief Inspector, N.W. Dist.	Asst. Engr., N. W. Dist.	20 : 9 : 14
Balcombe, W. O.	3rd Cl. Clerk, Provs.	2nd Cl. Clerk, Provs.	10 : 8 : 14

TRANSFERS.

Name.	Rank.	Transferred from.	To.	Date.
Smith, F. M.	Asst. Engr.	London Dist.	E. in C.O.	12 : 10 : 14
Payton, G. A.	,,	,,	,,	12 : 10 : 14
Hannaford, F. S.	,,	E. in C.O.	London Dist.	13 : 10 : 14
Poole, J.	,,	,,	London Power Dist.	9 : 11 : 14
Statters, J. E.	,,	North Midland	E. in C.O.	11 : 11 : 14
Perris, F. W.	3rd Cl. Clerk	South Eastern	Eastern	5 : 11 : 14
Reynolds, W. J.	,,	Eastern	South Eastern	6 : 11 : 14

STAFF CHANGES.

RETIREMENTS, ETC.

Name.	Rank.	District.	Date.
Longden, A.* . . .	Asst. Supt. Engr.	N. Eastern	1 : 1 : 15
Cropper, J. F.* . . .	3rd Cl. Clerk	N. Wales	20 : 9 : 14
Savage, G.† . . .	,,	N. Midland	17 : 11 : 14

* Superannuated.
† Appointed Superintendent of Registration, Straits Settlements.

DEATH.

Name.	Rank.	District.	Date.
Douglass, W. J. . .	Chief Inspector	Northern	5 : 10 : 14

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Supplement to Vol. VII, Part 1, April, 1914.

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

STATION LIST

OF

OFFICERS ELIGIBLE FOR MEMBERSHIP OF THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

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Supplement to THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, *Vol. VII, Part* 1, *April,* 1914.

STATION LIST.

BRITISH POST OFFICE.

ENGINEERING DEPARTMENT.

Name.	District.	Station or Section.
Engr.-in-Chief—		
Slingo, W.	E. in C.O.	—
Asst. Engrs.-in-Chief—		
Stubbs, A. J.	,,	—
Noble, W.	,,	—
Principal Power Engr.—		
Gunton, H. C.	,,	Power and Lighting.
Supt. Engr., London—		
Moir, A.	London	Denman St., S.E.
Suptg. Engrs. and Staff Engrs.—		
Stewart, D. M.	Sc. W.	Glasgow.
Tremain, F.	S. W.	Bristol.
Robb, J. McL.	S. M.	Reading.
McIlroy, R.	S. Wa.	Cardiff.
Lamb, J. F.	E.	Cambridge.
DeLattre, A. L.	E. in C.O.	Main Lines.
Martin, A. W.	,,	Telephone.
Purves, T. F.	,,	Designs.
Watts, A.	,,	Local Lines.
Gall, J. R. B.	,,	Test.
France, W. M.	,,	Equipment.
Eldridge, E. J.	N. M.	Nottingham.
Plummer, T.	N. Wa.	Shrewsbury.
Tandy, F.	S. E.	Croydon.
Sinnott, J.	E. in C.O.	Construction
Pollock, S. A.	,,	Research.
Trezise, J. M. G.	Power (London)	Central Power Stn.
Stretche, T. E. P.	N. W.	Preston.
Johnson, T. B.	N. E.	Leeds.
Elliott, J. R. M.	N.	Newcastle.
Medlyn, W. J.	S. Lancs.	Manchester.
Taylor, J. D.	Sc. E.	Edinburgh.
Booth, A. C.	E. in C.O.	Telegraph.
Shaughnessy, E. H.	,,	Wireless.
Asst. Suptg. Engrs. and Asst. Staff Engrs.—		
Taylor, J. E.	E.	Cambridge.
Longden, A.	N. E.	Leeds.
Fossett, J. H.	Power (London)	Central Power Stn.
Ramsay, M.	E. in C.O.	Equipment.
Gomersall, E.	S. M.	Reading.
Powell, W. H.	E. in C.O.	Power.
Henley, F. L.	,,	Test.
Waring, R.	London	Denman St.
Martin, J.	S. E.	Croydon.
Turner, E.	E. in C.O	Construction
Crompton, C.	Sc. E.	Edinburgh.
Asst. Suptg. Engs. and Asst. Staff Engrs.— con.		
Ivison, E. J.	E. in C.O.	Telephone.
Kennedy, D. H.	London	Denman St.
Evans, W. M.	Ire.	Dublin.
Greenham, G. F.	London	Denman St.
Kinsey, A. T.	S. W.	Bristol.
Wilson, H.	E. in C.O.	Designs.
Shackleton, J. M.	London	Denman St.
Cohen, B. S.	E. in C.O.	Research.
Aitken, R.	,,	Local Lines.
Lack, E.	,,	Telegraph.
Bailey, W. J.	,,	Equipment.
Batchelor, W. M.	N.	Newcastle.
Weaver, R. A.	Sc. W.	Glasgow.
Masaroon, R. G.	N. Wa.	Shrewsbury.
Sullivan, J. W.	N. W.	Preston.
Stanhope, J. H.	London	Denman St.
Mulligan, P.	N. M.	Nottingham.
Vooght-Cornish, H.	E. in C.O.	Power.
Price, J. P.	S. E.	Croydon.
Lewis, T.	N. M.	Nottingham.
Winny, W. H.	E. in C.O	Test.
Matthews, J. R.	,,	Power.
Hart, A. B.	,,	Telephone.
Hill, J. G.	,,	Research.
Twells, W. E.	,,	Main Lines.
Turner, L. B.	,,	Wireless.
Webber, Capt. O. T. O'K.	Ire.	Dublin.
Shorrocks, F. W.	E. in C.O.	Equipment.
Francis, F. W.	,,	Designs.
Stuart, D.	,,	Test.
Atkinson, J. W.	,,	Construction.
Brown, H. P.	,,	Telephone.
Lee, A. G.	,,	Local Lines.
Brown, Henry	,,	Main Lines.
Walters, E. H.	,,	Power.
Hardie, J.	Sc. W.	Glasgow.
Parkinson, F. S.	S. Lancs.	Manchester.
Stannage, G.	S. Wa.	Cardiff.
Comport, G. H.	S. M.	Reading.
Youngs, C. J.	S. Wa.	Cardiff.
Chapman, A. E.	S. W.	Bristol.
Barber, J. W.	S. Lancs.	Manchester.
Terras, J. S.	N. W.	Preston.
Gilbert, A. B.	Sc. E.	Edinburgh.
Wolstenholme, C. S.	N. E.	Leeds.
Baldwin, F. G. C.	N.	Newcastle.

Name.	District.	Station or Section.
Exec. Engrs. and Engrs. 1st Cl.—		
Turner, J. W.	N.	Darlington.
Titterington, E. T.	E.	Cambridge.
Moon, W.	N. W.	Lancaster.
Gibbons, J. E.	Ldn.	South-West External.
Crane, J.	S. Lancs.	Birkenhead.
Wood, E. J.	Ldn.	North-West External.
Slader, E.	Sc. E.	Aberdeen.
King, H.	N. M.	North'mpton.
Whitehead, J.	S. M.	St. Albans.
Partridge, G. N.	S. Wa.	Cardiff (External).
Thow, J. H.	Ldn.	Central Telegraph Office.
Herbert, T. E.	N. M.	Sheffield.
Chapman, C. H.	E. in C.O. (Mt. Plnt.)	Test.
Price, H. C.	Ldn.	North-East Internal.
Farrand, E. H.	N. E.	Leeds (External).
Jefferyes, G. C.	Sc. E.	Dundee.
Peck, G. A.	N.	Middlesbro'.
Brown, J. L.	Ldn.	Centre External.
McInnes, H. A.	S. M.	Oxford.
Sheldon, J.	S. W.	Exeter.
Allan, W.	Sc. W.	Glasgow (Maint'nce).
Sirett, A. W.	S. Wa.	Gloucester.
Eames, A. J.	S. Lancs.	Liverpool (External).
Eames, E. J.	S. E.	Tunbridge Wells.
Gibbins, F. E.	N. Wa.	Chester.
Callender, R. W.	S. M.	Kingston-on-Thames.
Bascombe, A.	Ldn.	West External.
Gilpin, G. E.	N.	Newcastle (S.E's. O.)
Haynes, J. H.	S. M.	Guildford.
Henshilwood, G.	S. E.	Canterbury.
Wood, P. T.	Ldn.	Central Internal.
Best, F. W.	N. W.	Rochdale.
Cunningham, R.	Sc. W.	Paisley.
Magnall, A.	S. Lancs.	Manchester (West).
Wallace, G. S.	,,	Manchester (Internal).
Nimmo, R.	S. W.	Bournemouth
Roach, C. G.	,,	Plymouth.
Fraser, J.	E. in C.O.	Telegraph.
Hunt, J. A.	Ldn.	City External.
Tattersall, C. E.	,,	North External.
Appleby, C. W.	,,	South-East External.
Exec. Engrs. and Engrs. 1st Cl.—con.		
Jackson, C. A.	N. Wa.	Shrewsbury (S.E's. O.).
Gray, A.	N. E.	York.
Kitchen, H.	N.	Newcastle (Internal).
Richardson, J	Sc. W.	Glasgow (Light Construction).
Brown, J. S.	S. M.	South'mpton
Wilson, R.	Ldn.	West Internal.
McMorrough, F.	N. E.	Lincoln.
Giffen, A. E.	N. Wa.	Hanley.
Kemp, H.	,,	Shrewsbury.
Whillis, C.	N. W.	Carlisle.
Nichols, A. R.	N. M.	Peterboro'.
Laslett, G.	Ire.	Belfast.
Mackintosh, A.	Sc. W.	Glasgow (North).
Tinsley, W. S.	N. E.	Bradford.
Richardson, G.	N. Wa.	Birmingham (Inner).
Pennington, W.	S. Wa.	Swansea.
Cheshire, F. W.	E.	Colchester.
Gwilliam, W. J.	S. M.	Reading.
I'Anson, R.	N. M.	Nottingham.
Andrews, J. R.	N.	West Tyne.
Upton, S.	N. W.	Blackburn.
Wakefield, J. H. M.	S. Wa.	Newport.
Mercer, C. J.	Sc. E.	Inverness.
Bullock, A. H.	N. M.	Leicester.
Crisp, C. T.	S. E.	Brighton.
Smith-Bunney, T.	Power (Ldn.)	Central Power Stn.
Ridd, P. J.	Ldn.	S. E's. O.
Wright, A.	,,	South Internal.
Bailey, F. H.	E. in C.O. (Mt. Plnt.)	Test.
Alexander, R.	Sc. E.	Edinburgh.
Shaw, J. H.	Ire.	Dublin (West).
Baxter, J.	S. Wa.	Hereford.
Gillespie, J. T.	Sc. E.	Edinburgh (S. E's. O.).
Halton, R.	S. M.	Reading (S. E's. O.).
Rolfe, W. J.	N. W.	Preston.
Billingham, G. W.	N. Wa.	Bangor.
Brown, James	Ldn.	S. E's. O.
Pink, E. A.	S. W.	Bristol.
Hines, J. G.	Ldn.	City Internal.
Fulcher, H. W.	Power (Ldn.)	Mt. Pleasant.
Coote, J. F.	E. in C.O.	Research.
Cornfoot, T.	S. Lancs.	Liverpool (Internal).
Carter, W. G.	Power (Ldn.)	G.P.O.
Stubbs, W. J.	N. M.	Coventry.

Name.	District.	Station or Section.
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Lakey, T.	E.	Norwich.
Wise, F. H.	E.	Ilford.
Patterson, T.	S. E.	Croydon.
Scott, W.	S. Wa.	Cardiff (S. E's. O.)
Horton, F. D.	Sc. W.	Hamilton.
Gillett, E. J.	N. Wa.	Birmingham (Outer).
Tattersall, J. T.	N. E.	Hull.
Cardrey, A. G.	Ldn.	East External.
Wells, R. A.	E. in C.O	Telephone.
Shea, J.	S. Lancs.	Manchester (East).
Bramwell, J. T.	,,	Manchester (S. E's. O.).
Cameron, J.	Sc. W.	Glasgow (S. E's. O.).
Francis, E. S.	N. E.	Leeds (Internal).
Jenkins, I. H.	E. in C.O.	Equipment.
Thompson, H. S.	,,	Telephone.
Newton, E. W.	N.	Newcastle (External).
Ryall, J. B.	S. Wa.	Cardiff (Internal).
Kingston, J. R.	Power (Ldn.)	Savings Bank.
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Cawood, S. D.	Sc. E.	Dundee.
Bryant, S. G.	S. Wa.	Hereford.
Poole, J.	E. in C.O.	Power.
Wood, A. H.	London	North-west External.
Sirett, C. J.	S. M.	Southampt'n
Barr, F.	N. M.	Sheffield.
Wilson, F. R.	N.	West Tyne.
Cowie, F. E. W.	Sc. E.	Aberdeen.
France, G. S.	N. Wa.	Birmingham (Outer).
Dickson, J.	S. Lancs.	Manchester (S. E's. O.).
Newlands, T. H.	E. in C.O.	Telegraph.
Ashton, H. E.	S. E.	Croydon (S. E's. O.).
Eaton, G. J.	N. Wa.	Bangor.
Burton, G. M.	N. E.	Leeds (S. E's. O.).
Powning, W. H.	S. Wa.	Swansea.
Roche, T.	Ire.	Cork.
Connell, G. W.	London	Central Telegraph Office.
Teggins, A. W.	S. M.	Reading.
Bannister, G. W.	S. W.	Exeter.
Hook, G. H. J.	E. in C.O	Local Lines.
Patrick, J.	Sc. E.	Edinburgh.
Devonshire, T. E.	S. M.	Southampt'n.
Langley, J. T.	London	Centre External.
Asst. Engrs.—con.		
Brien, J. G.	E. in C.O.	Designs.
Scott, A.	Sc. E.	Edinburgh (S. E's. O.).
Roberts, A. H	E. in C.O	Telegraph.
Baxter, E. H.	,,	Equipment.
Osborne, F. C.	,,	Power.
Brown, J.	Sc. E.	Edinburgh (S. E's. O.).
McIntosh, D.	,,	Edinburgh.
Partridge, T. T.	E. in C.O	Main Lines.
Wilby, E. J.	,,	Telephone.
Scarr, W.	E.	Cambridge (S. E's. O.).
Steed, H. P.	London	West External.
Hatfield, W. A.	E. in C.O	Research.
McNicol, A. J.	S. E.	Croydon.
Markwick, J. J.	E. in C.O.	Designs.
Cockshott, W. J.	S. W.	Bristol (S. E's. O.).
Simmance, J. H.	E. in C.O.	Telephone.
Bartholomew, S. C.	,,	Construction.
Hook, R. M.	,,	Telegraph.
Fletcher, J. F.	S. Lancs.	Manchester (S. E's. O.).
Lomas, W.	N. M.	Leicester.
Leigh, J. H.	S. Lancs.	Manchester (West).
Addey, F.	E. in C.O.	Wireless.
Blight, W. O.	,,	Telephone.
Edgerton, T. H.	London	South Internal.
Robinson, C.	E. in C.O.	Research.
Park, J.	S. W.	Bristol.
Horner, F. H.	N. Wa.	Chester.
Picker, H. F.	E. in C.O.	Main Lines.
Chandler, A. E.	,,	Local Lines.
Giles, H. W.	,,	Equipment.
Macpherson, H.	S. M.	Oxford.
Lucas, J. G.	E. in C.O.	Telephone.
Watson, D. W.	London	City External.
Vernon, G. H.	N. E.	Bradford.
Smart, E. V.	London	East External.
Beetlestone, M. A.	,,	North External.
Allen, F. J.	E. in C.O.	Designs.
Hunter, H. J.	S. W.	Plymouth.
Williams, R. H.	London	West Internal.
Morris, A. C.	N. M.	Nottingham.
Woollard, F. W.	London	Centre Internal.
Angwin, A. S.	Sc. W.	Glasgow (Light Construction).
Murray, J. K.	,,	Glasgow (M'ntenance).
Stone, H. C.	London	City External
Roberts, P. A.	,,	West External.

Name.	District.	Station or Section.
Asst. Engrs.—con.		
Coates, G. A.	N. E.	Hull.
Beasley, B. J.	S. M.	Reading (S. E's. O.).
Davidson, J.	Ire.	Belfast.
Bellwood, G. F.	N.	Newcastle (S. E's. O.).
Hetherington, T.	Sc. W.	Glasgow (S. E's. O.).
Cowie, J.	S. E.	Brighton.
Jones, E. P.	E. in C.O.	Power.
Stewart, W.	Sc. W.	Glasgow (S. E's. O.).
Hilyer, W. J.	E. in C.O.	Telephone.
Collinson, T. R.	N.	Darlington.
King, R. T.	E. in C.O.	Equipment.
Phillips, A. C.	S. W.	Bournem'th.
Platt, W.	S. Wa.	Cardiff (S. E's. O.).
Lockhart, J.	E. in C.O.	Designs.
Jones, J.	N. Wa.	Shrewsbury.
Beer, G. F.	S. Lancs.	Birkenhead.
Bassett, S. W.	N. M.	Nottingham (S. E's. O.).
Fleming, G.	Sc. W.	Hamilton.
Doak, H.	Ire.	Dublin.
Browne, F. G.	N. M.	Coventry.
Taylor, J. L.	E. in C.O.	Telegraph.
Sharpley, A. J.	London	North External.
Hall, F. M.	,,	North-east Internal.
Gadsby, G. J.	E. in C.O.	Equipment.
Jolley, L. B. W.	,,	Power.
Taylor, C. A.	,,	Test (Mount Pleasant).
Sanger, P. M.	S. E.	Croydon (S. E's. O.).
Robertson, J.	Sc. E.	Edinburgh.
Finlayson, W. J.	N. W.	Preston (S. E's. O.).
Hedley, J.	E. in C.O.	Telephone.
Gray, W. J.	,,	Local Lines.
Shepherd, G. M. B.	,,	Research.
Maddock, G. M.	,,	Equipment.
Blick, F.	London	South-west External.
Brocklesby, C.	N. Wa.	Birmingham (Inner).
Walker, J. C.	N. E.	Bradford.
Warnock, J. W.	Sc. W.	Glasgow (Light Construction).
Anson, B. O.	E. in C.O.	Telephone.
Perrin, E. S.	,,	Wireless.
Timmis, A. C.	N. M.	Leicester.
Cave-Browne-Cave, N. F.	N. Wa.	Hanley.
Dunsheath, P.	E. in C.O	Power.
Lawson, C. G.	Power (London)	Mount Pleasant.
Redhead, C. H.	Ire.	Dublin.

Name.	District.	Station or Section.
Asst. Engrs.—con.		
Reid, F.	E. in C.O.	Construction.
Witherby, J. C.	Sc. W.	Glasgow (S. E's. O.).
Greening, A. C.	London	Centre Internal.
Warner, A.	,,	City Internal.
Payton, G. A.	,,	South Internal.
Fraser, A.	E. in C.O.	Wireless.
Davey, F. W.	,,	,,
Glover, J. B.	N. W.	Blackburn.
Leigh, C.	E. in C.O.	Main Lines.
Tebbits, J. S.	N. Wa.	Shrewsbury (S. E's. O.).
Wenman, H. E. A.	London.	City External.
Crocker, J. R.	E.	Cambridge
Jack, J. A.	Sc. W.	Glasgow (North).
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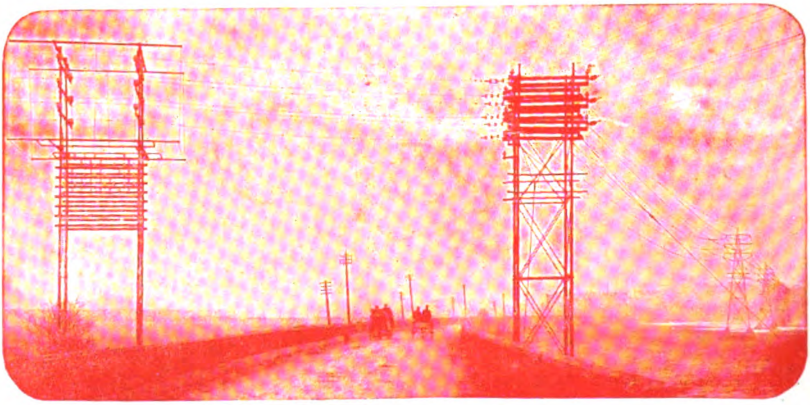

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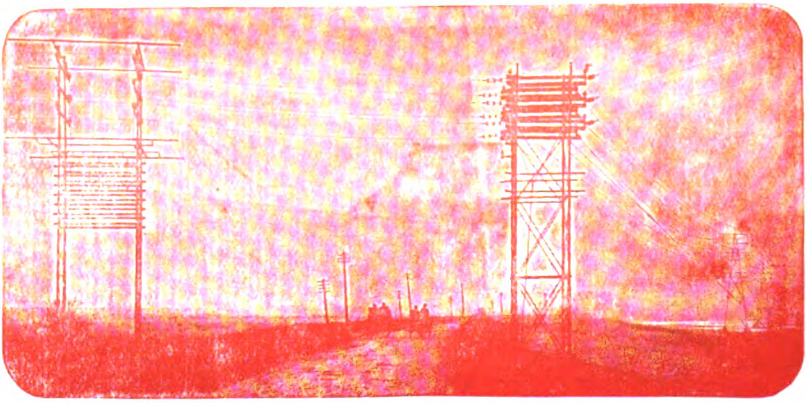

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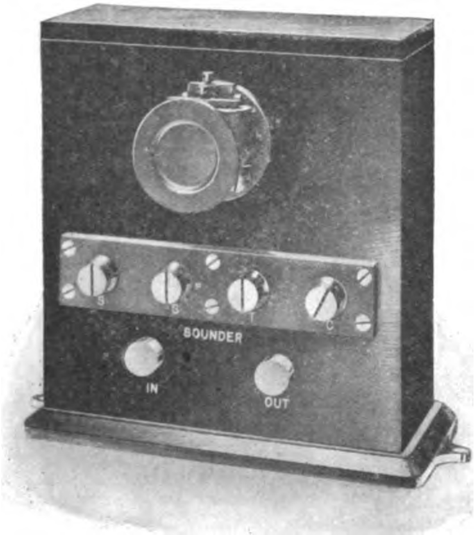

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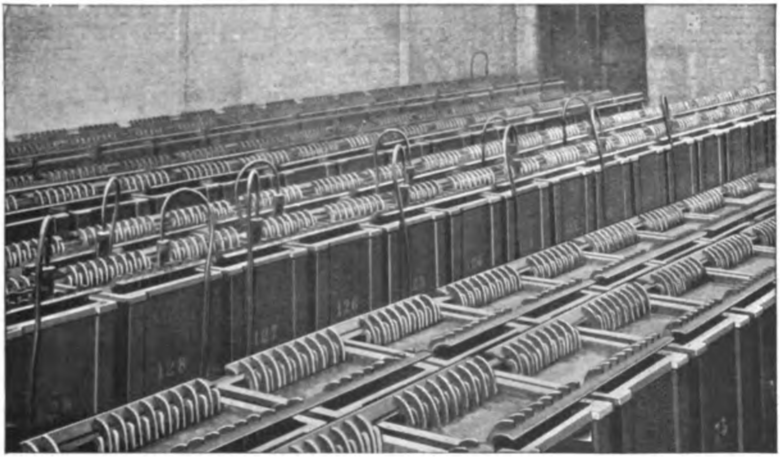

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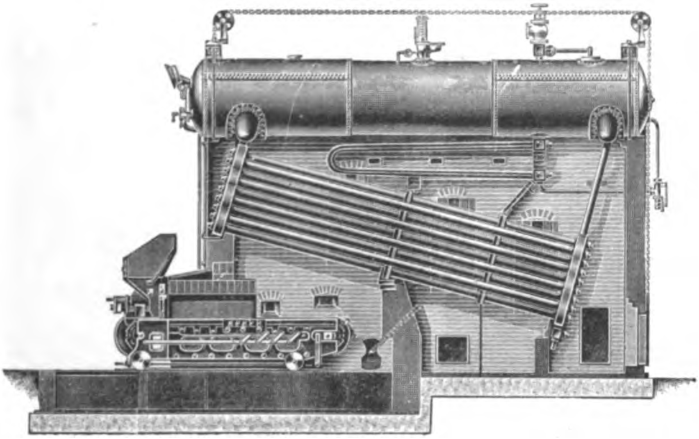

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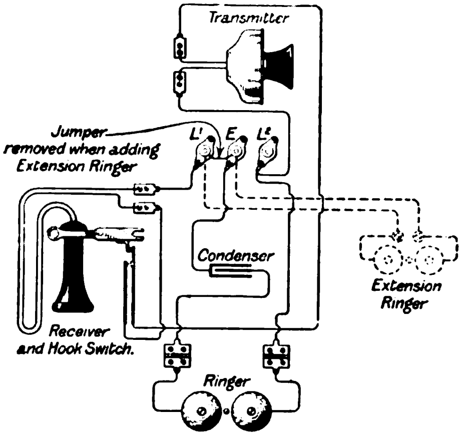
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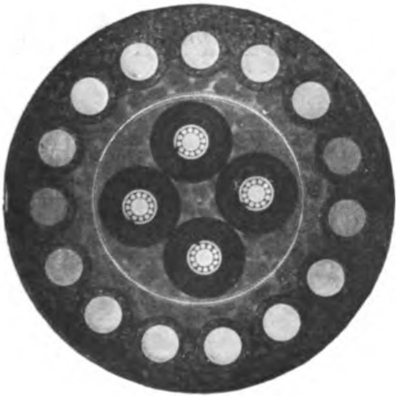

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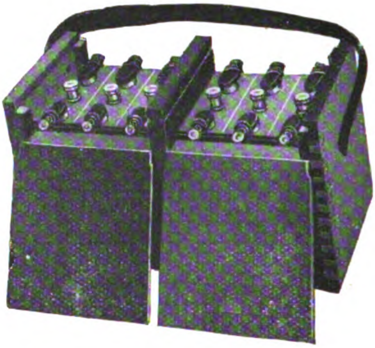

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